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Materials requirements planning: an organizational perspective

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MATERIALS REQUIREMENTS PLANNING: AN ORGANIZATIONAL PERSPECTIVE

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THESIS

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AN ORGANIZATIONAL PERSPECTIVE

by

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ABSTRACT

This thesis was an investigation of the organizational impacts of materials requirements planning (MRP) on using companies. Five industrial facilities were visited initially, and three locations were selected for follow-on study. Data were collected through interviews with personnel engaged in material management and production activities. Five hypotheses were identified and evaluated. Hypotheses addressed the following areas: organizational structure, work content, departmental interdependence, informal systems and employee displacement. The investigation revealed that MRP produces significant effects on all areas studied except informal systems. Recorded effects of MRP on informal systems were inconclusive, and that hypothesis was not evaluated. The majority of recorded effects were a result of MRP requirements for computer processing of information, increased record accuracy and integration of functional areas. Frameworks for follow-on studies were suggested.

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I. INTRODUCTION

Effective management of raw material and semi-finished production inventories has been a subject of increasing concern in both public and private sector industries in recent years. This concern has been partially due to the realization by business executives and senior government officials that effective inventory management has a major impact on the success of any industrial organization. Previously, top-management emphasis had been directed toward manufacturing or production efficiencies with inventory management occupying an ancillary role.

The added emphasis of recent years has fostered the development of new inventory management techniques. This thesis is concerned with one of the new techniques -- Materials Requirements Planning (MRP).

A. HISTORICAL PERSPECTIVE

Though recent economic factors have generated new material management methods, the general inventory problem of how much material to carry and how often to replenish the supply was addressed early in this century. Many of the early developed inventory models are still in use today.

The economical order quantity (EOQ) model, developed by Harris at the turn of the century, has become a basic inventory management procedure. The EOQ model was designed to minimize the combined costs of ordering and holding material in inventory.

Seventy-five years after conception, the EOQ model can be found in almost every business and material management text and is regarded as one of the most successful early scientific management techniques, and several contemporary inventory models are adaptations of Harris' work [1:5].

ABC or 20-80 analysis is another dated technique that retains a prominent place in inventory management. This technique was based on an economic phenomenon observed by the Italian economist Pareto (1848-1923). Applied to inventory management, ABC analysis holds that a small percentage of the total number of items in inventory (approximately 20 percent) accounts for a large percentage of the total inventory value (approximately 80 percent). With this model, inventory management is mainly directed at the high value A items with lower value B and C items receiving successively less attention [2:385].

Other methods, including order-point techniques, aggregate inventory management and stock replenishment, have all been used to manage modern inventories. All of the above techniques, however, were developed prior to the computer-assisted information-processing era. They were statistical inventory control approaches that reflected the limited data handling capacity at the time of their development.

The commercial availability of computers in the mid 1950s ushered in a new era of business logistics and inventory control. In light of the new technology, attempted refinement of old models eventually gave way to fundamentally different

approaches. In the area of manufacturing inventory management, the most successful innovation has become known as materials requirements planning (MRP).

MRP is a technique of managing production inventories that takes into account the specific timing of material requirements. Like other inventory control models, MRP has the objective of minimizing inventory investment consistent with meeting a given production plan. Unlike other models, MRP is heavily dependent on modern computer processing of information and integrated data-base management.

Although its use is now widespread and continues to grow, many companies have found MRP to be a difficult tool to manage from both technical and human-factor perspectives. To date, however, most MRP problem analyses have dealt with technical issues or the correction of erroneous system input records.

B. INTENT

The intent of this thesis was to report on an investigation of the organizational impacts of materials requirements planning on the material management organization of using companies. The investigation was designed to identify potential human and organizational impact areas associated with MRP use; determine the existence, nature and severity of resultant effects in actual practice; and perform appropriate analysis. Conclusions and recommendations were also presented.

Chapter II of this report provided background information on the MRP process. Information was detailed to the degree

necessary to allow the reader to understand the remainder of the report and gain an appreciation of the MRP process. Chapter III summarized the results of a review of literature on MRP system operational problems. This chapter provided additional background and assisted in the preliminary identification of hypotheses tested in the investigative phase of the research. Chapter IV provided the framework for the investigation. The conceptual model used in the analysis was illustrated, and hypotheses and data sources were discussed. Chapter V presented the data and results of the analysis. The analysis dealt with MRP-induced changes recorded in this research. A complete picture of companies or personnel functions was not intended. Conclusions and recommendations were provided in the final two chapters.

In the development of this thesis, no previous knowledge of MRP on the part of the reader was assumed as the background chapters provide sufficient information. A basic knowledge of modern data-processing techniques would be beneficial to the reader in understanding MRP's demands. Such knowledge, however, is not essential to the understanding of the process or this report, and specifics of data processing were not covered in the background material. A general familiarity with business logistics terminology and traditional inventory models other than MRP was assumed. Readers requiring additional background in this area are referred to Dean S. Ammer, Materials Management, or Coyle and Bardi, Business Logistics.

C. ASSUMPTIONS AND LIMITATIONS OF THE STUDY

The central assumption of this study was that MRP impacts organizational elements of using companies. It was further assumed that these impacts may in turn produce human-related difficulties that have the potential to reduce MRP system effectiveness. It was recognized that system technical problems may also exist. It was assumed, however, that non-technical organizational influences could be studied separately and that the understanding of these influences may provide insight into MRP effectiveness problem areas.

As another assumption, the value of MRP, where successfully operated, was accepted. No attempt was made to quantify MRP success in terms of standard measures like inventory turnover, valuation or service level, and comparisons with other inventory control techniques were made only to highlight aspects of the MRP process. Qualitative judgments by industry representatives of MRP's value were, however, presented in the analysis.

This study was also subject to several limitations. Of central importance was the restriction of the study to the effects of MRP on raw material and work-in-process material management functions. Possible effects of MRP on marketing, accounting and finance, engineering, production and computer services were not explicitly addressed although some aspects of their interfaces with the indicated material management functions were considered.

A second important limitation, due to time and travel restrictions, led to the selection of industrial study locations in the general geographic area surrounding the San Francisco Bay area. As a result, companies represented in the data reflect the predominantly light, job-lot processing, electronic-industry nature of the area. However, data were collected from as many industry types as practicable.

D. METHODOLOGY

Prosecution of this research followed the general sequence of steps discussed in this section. First, suitable background preparation was completed. Preparation included the study of the MRP process and a review of operational considerations discussed in the logistics management literature. Areas of concern used in the development of study hypotheses were then identified.

The second major step involved initial discussions with industry personnel engaged in the actual use of MRP systems. Based on discussions, MRP users that provided a variety of company characteristics and industry types were identified, and their willingness to cooperate with research requirements was secured. Initial discussions also assisted in the formulation of hypotheses which were identified at the completion of that stage of the study.

During the third major stage, a conceptual model used in the remainder of the research was constructed. The model provided a framework for the major data collection gained

during ensuing follow-on interviews with selected industry personnel.

In the final research stage, a subjective analysis of the data relative to the conceptual model was performed. Development of conclusions and recommendations based on the analysis completed the research.

II. MRP: A DESCRIPTION OF THE PROCESS

Pre-computer era inventory management techniques involved some method to control inventory costs consistent with a desired service level. Computer-assisted materials requirements planning can deal with inventory cost reductions without experiencing corresponding service level reductions. This is accomplished by eliminating the averaging processes of statistical inventory management and substituting a specific calculation of what parts to place in inventory and when.

In addition to reduced inventory levels, successful MRP operation offers users several important management tools that are by-products of the basic process. The purpose of this chapter is to describe the objectives of MRP and discuss the system's application, restrictions and basic processing logic. Details of design and a brief description of system types are also presented.

A. MRP OBJECTIVES

MRP's basic objective is to determine discrete period demands for product component parts whether purchased or manufactured. Once determined, this information can be used in several ways to accomplish desired inventory goals.

1. System Action Elements

The fundamental MRP activity involves the correction of inventory order action. Action refers to procurement or

production and can be either new action or a revision to a previous plan. Specifically MRP can initiate the following activities.

- A new purchase requisition
- An order placed with production
- An increase or decrease in order quantity
- An order cancellation or suspension
- Advancement or deferment of order due date

The above actions are essential to control inventory cost and production service level. The knowledge of the timing and quantity of actual requirements makes it possible to carry in inventory only material that will soon be utilized [3:45].

2. Program Planning

Successful accomplishment of MRP objectives implies the use of several tools provided by the process. The same logic that can determine if a manufactured item needs to be expedited or de-expedited in order to meet an assembly schedule can easily produce a priority planning document to assist in production control. Introduction of equipment capacity information results in a document used for workload leveling and shop capacity planning. The goal of both reports is improved production efficiency, economy and increased plant utilization [3:145-156].

Another tool provided by MRP is the unique ability to replan either in response to actual business dynamics or during simulation for planning. Using the above modules and

the speed and data handling efficiency of modern computers, the effects of product or production changes can be readily determined in terms of material requirements and plant capacity [3:142].

B. FACTORS IMPACTING MRP APPLICATION

MRP is a management technique to be used with physical supply and work-in-process manufacturing inventories. The understanding of several characteristics of this type of inventory is necessary to understand the process.

1. Manufacturing and Distribution Inventory

The purpose of distribution inventory is to meet customer demand whether the customer is a final consumer or another producer. Such demand is typically made up of varying demands of several sources. Exact requirements are difficult to predict, and distribution inventory levels are usually a resultant of production efficiency, marketing requirements and sales forecast considerations.

Manufacturing inventory, on the other hand, exists only to be converted to a finished product. Inventory investment is dictated by manufacturing considerations, and the production plan is the sole source of demand. Financial trade-offs between distribution inventory investment and sales revenue realized through availability do not exist in manufacturing inventories. The fundamental differences in inventory types should be reflected in different management approaches [3:19].

2. Independent and Dependent Demand

A second important concept related to the one described above is the difference between dependent and independent demand. The demand for a finished product is independent in the sense that it must be forecasted as opposed to being calculated. Once the desired quantity of finished goods is determined, by whatever manner, the required amounts of raw materials and purchased or manufactured components and subassemblies is set, and the dependent demand for these materials can be calculated. By knowing the production process as well as product composition, questions concerning the when of material requirements as well as how much can be addressed [3:22].

3. Nature of Manufacturing Demand

Manufacturing firms have two fundamental alternatives for inventory management technique: stock replenishment or statistical inventory control and material requirements planning. Each technique has a demand assumption. Statistical methods like EOQ assume a relatively constant and uniform demand. Models utilizing the statistical approach are based on forecast demand during lead time and compensate for forecast error by using a safety stock.

MRP can be utilized with, but is not dependent on, discontinuous, non-uniform demand which is characteristic of manufacturing firms. Narrowly defined, MRP is designed to translate finished goods production requirements into time-phased net requirements for each component inventory

item needed to meet the production schedule [3:21]. MRP emphasis is placed on calculation vice forecast and timing of period requirements.

C. PREREQUISITE SYSTEMS

Certain tools must be available for MRP to be used. These tools do not represent criteria for applicability because even if currently absent, they can be made available by management decision. However, each has a fundamental interface with MRP processing logic.

1. Master Production Schedule

Simply stated, a master production schedule is a list showing how many of each finished item to make in each time period in the future. Here independent demand is forecast from customer orders, to stock requirements, sales forecasts, and other marketing factors. The master production schedule considers manufacturing capacity, attempts to level out sales peaks and valleys and provides the single demand input to the MRP system. As will be seen later certain schedule design factors, such as planning horizon, must be considered in tandem with MRP so that MRP can accommodate schedule changes [4:471].

2. Bill of Materials

In order to translate the master production schedule into physical supply requirements a bill of materials is required. A bill of materials is a parts list. It lists for each end item, all component parts and subassemblies,

either manufactured or purchased, and their required quantity per assembly. It is essential that all part numbers be definitively identified and that any changes are added to the bill of materials [3:39].

3. Inventory Records

The MRP system not only calculates requirements, but it identifies shortages and triggers required manufacturing or purchasing action. As such, MRP must have immediate access to inventory records. The inventory file must contain accurate lead time information in addition to stock level status to be used in the MRP system [3:50]. Figure 1 summarizes the relationships discussed in the above two sections [5:84].

D. MRP PROCESSING LOGIC

MRP operates on the bill of materials, master production schedule and inventory record files to determine discrete period demands for each item of inventory. The demand calculation forms the basis for all the output reports provided by the system. Major elements of MRP system processing are described below:

1. The Product Structure Tree

The product structure tree illustrated by Figure 2 indicates the use of data from the master schedule, bill of materials and the inventory status file. Requirements for level 0 end item A taken from the master production schedule are easily expanded into requirements for all components and

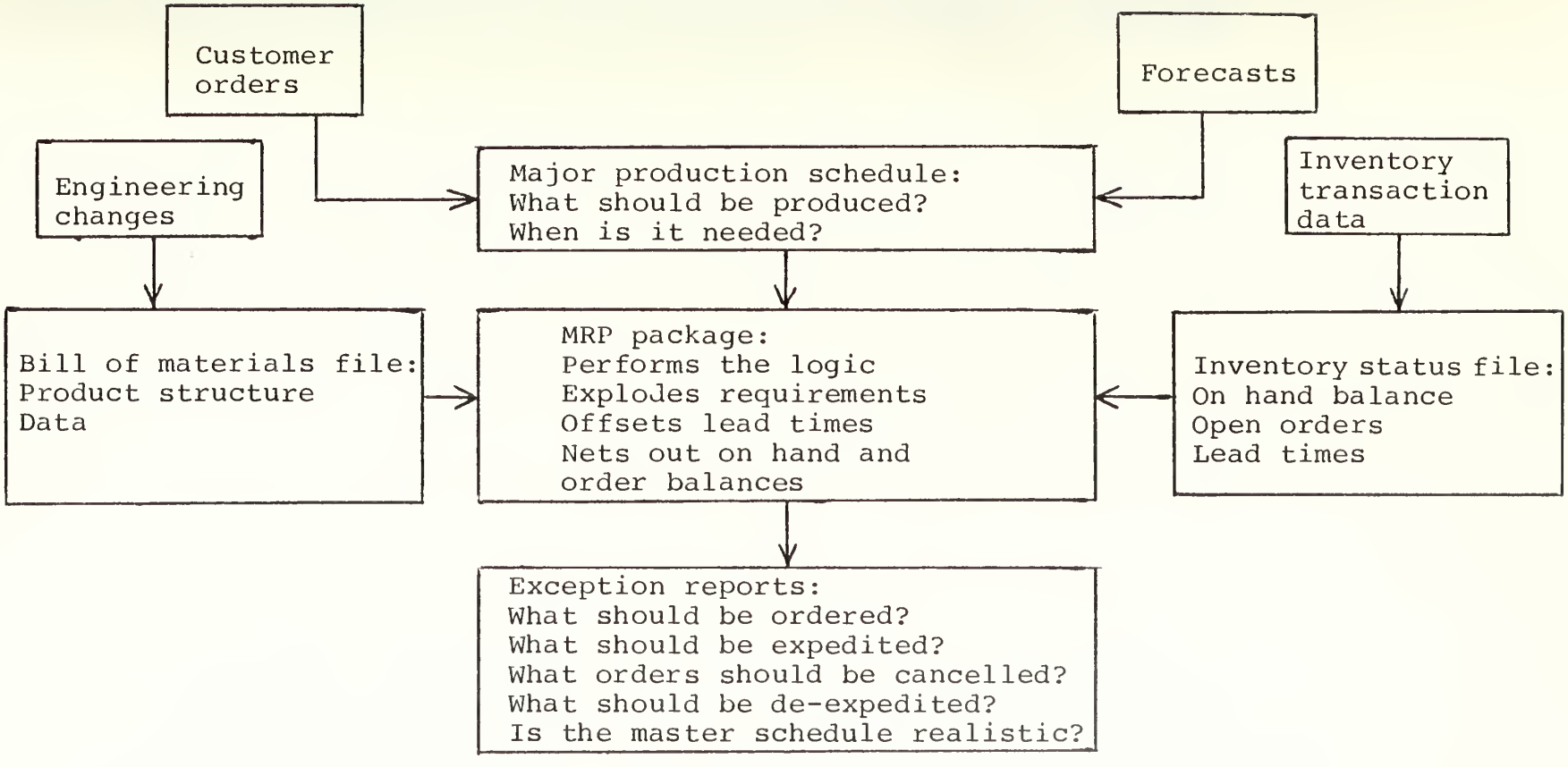


Figure 1. Elements of a MRP System

Source [5:84]

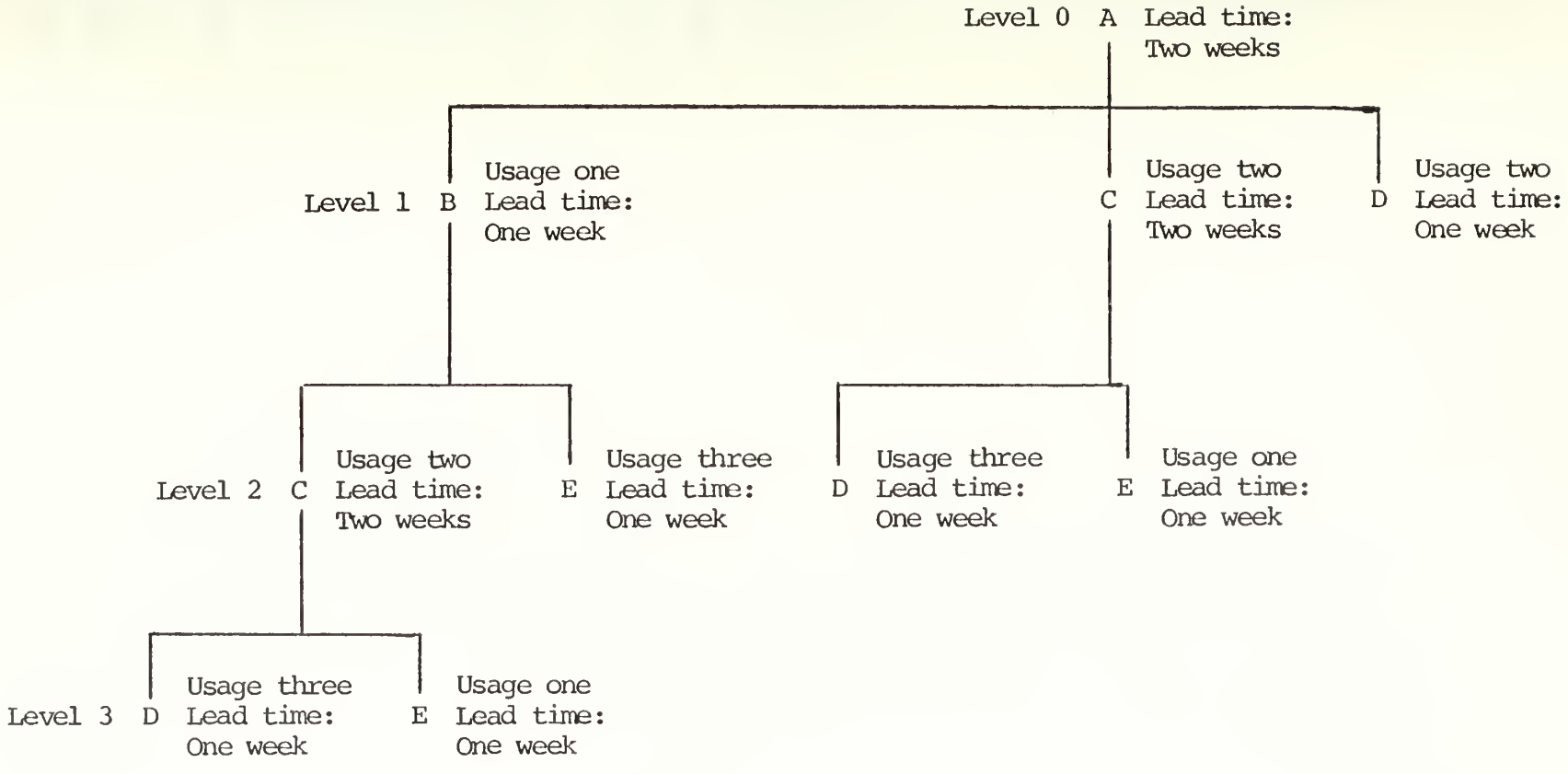


Figure 2. Product Structure Tree for End Item A

Source [4:484]

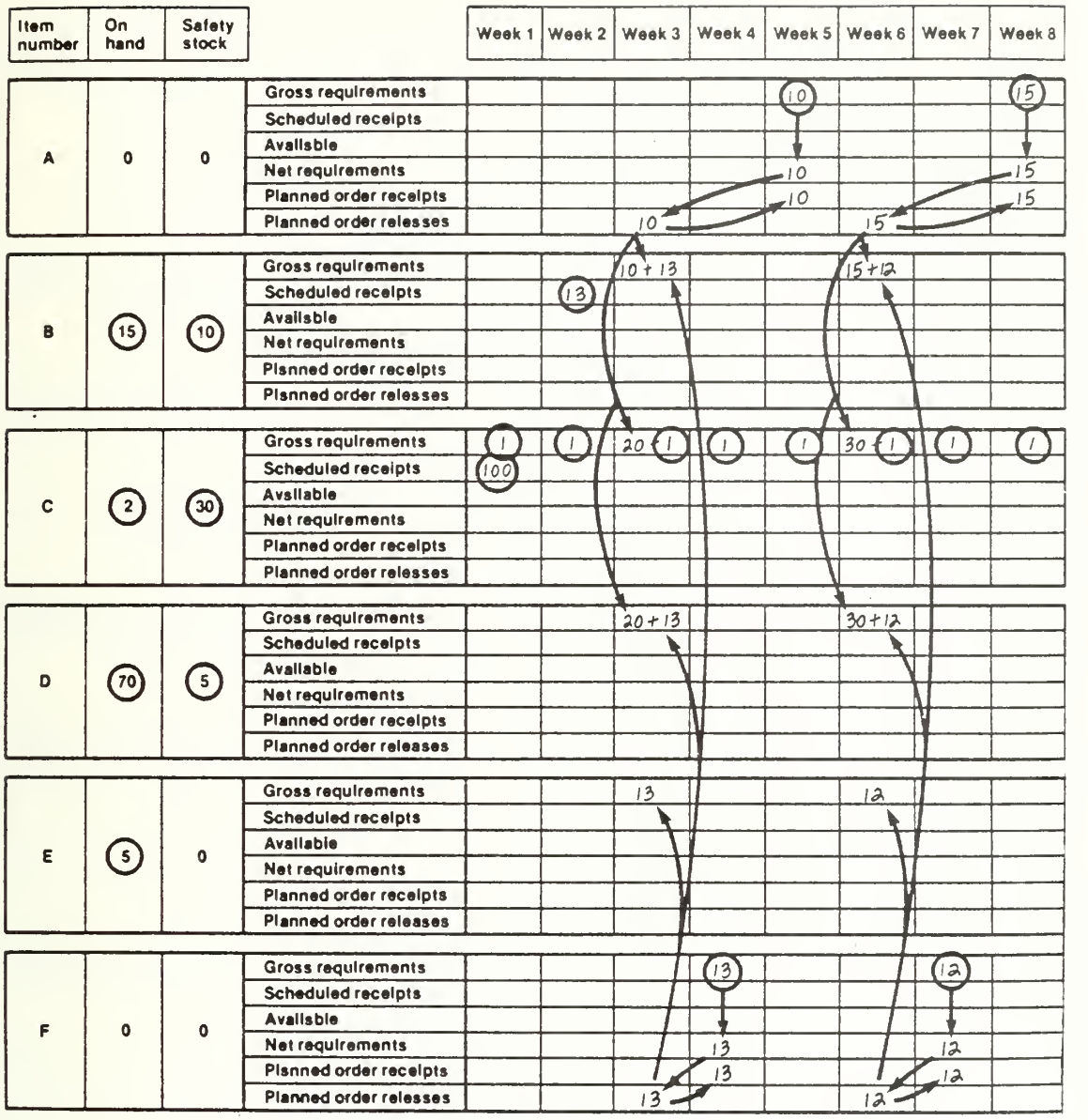
subassemblies whether purchased or manufactured. All level 1 components must be available to produce one product A. Assembly lead time and product A's required quantity fix the time and quantity of level 1 components required. As can be seen from Figure 2, an individual item may be used in one or more subassemblies in one or more levels. Items may also appear in more than one product. Quantities of item E are reflected in inventory figures for item C and item B. For computer calculations of when an item will be needed, it is identified with its lower level only [4:487].

2. The Requirement Explosion Process

The heart of the MRP calculation process is requirements explosion. In the example on Figure 3, the master production schedule has called for 10 units of end product A in week 5 and 15 units in week 8. Item F is also an end item and has several of the components and subassemblies used in product A. Requirements for item F are also indicated.

Taking item A's assembly lead time into account and working backward from the week 5 requirement, final assembly must begin week 3, and all level 1 subassemblies must be available at that time. Ten A items will demand 10 B items and 20 C and D items to satisfy level 1 requirements only. (See Figure 2.) Each level's requirements are developed in succeeding explosions.

As is illusted in Figures 4 and 5, inventory levels, safety stock requirements and lead time information are combined with exploded item gross requirements to identify



Notes: (1) Circled on hand and safety stock items indicate information on file at start of explosion process.

(2) Circled gross-requirements for item C are independent spare parts requirements.

Figure 3. MRP Explosion Process (FIRST Level)

Source [4:490]

Item number	On hand	Safety stock		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
A	0	0	Gross requirements					10			15
			Scheduled receipts								
			Available								
			Net requirements								15
			Planned order receipts					10			15
			Planned order releases			10			15		
B	15	10	Gross requirements			23			27		
			Scheduled receipts		13						
			Available	5	18	18					
			Net requirements			5			27		
			Planned order receipts			5			27		
			Planned order releases		5			27			
C	2	30	Gross requirements	1	10+1	21	1	54+1	31	1	1
			Scheduled receipts	100							
			Available								
			Net requirements								
			Planned order receipts								
			Planned order releases								
D	70	5	Gross requirements			33			42		
			Scheduled receipts								
			Available								
			Net requirements								
			Planned order receipts								
			Planned order releases								
E	5	0	Gross requirements		15	13		81	12		
			Scheduled receipts								
			Available								
			Net requirements								
			Planned order receipts								
			Planned order releases								
F	0	0	Gross requirements				13			12	
			Scheduled receipts								
			Available								
			Net requirements				13			12	
			Planned order receipts				13			12	
			Planned order releases			13			12		

Figure 4. MRP Explosion Process (Second Level)

Source [4:492]

Item number	On hand	Safety stock		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
A	0	0	Gross requirements					10			15
			Scheduled receipts								
			Available								
			Net requirements								15
			Planned order receipts					10			15
			Planned order releases			10			15		
B	15	10	Gross requirements			23			27		
			Scheduled receipts	5	13						
			Available		18	18					
			Net requirements			5			27		
			Planned order receipts			5			27		
			Planned order releases		5			27			
C	2	30	Gross requirements	1	11	21	1	55	31	1	1
			Scheduled receipts	100							
			Available	72	71	60	39	38			
			Net requirements					17	31	1	1
			Planned order receipts					17	31	1	1
			Planned order releases			17	31	1	1		
D	70	5	Gross requirements			51 + 33	93	3	3 + 42		
			Scheduled receipts								
			Available	20	20	20					
			Net requirements			64	93	3	45		
			Planned order receipts			64	93	3	45		
			Planned order releases		64	93	3	45			
E	5	0	Gross requirements		15	17 + 13	31	1 + 81	12 + 1		
			Scheduled receipts								
			Available		5						
			Net requirements		10	30	31	82	13		
			Planned order receipts		10	30	31	82	13		
			Planned order releases	10	30	31	82	13			
F	0	0	Gross requirements				13			12	
			Scheduled receipts								
			Available								
			Net requirements				13			12	
			Planned order receipts				13			12	
			Planned order releases			13			12		

Figure 5. MRP Explosion Process (Third Level)

Source [4:493]

net requirements and indicate appropriate procurement or production action. For example item B in Figure 5 indicates a gross requirement of 23 units in week 3. Taking planned receipts, the on-hand balance, item B lead time and desired safety stock into account the MRP process generates an order release of an additional 5 units for week 2 [4:493].

3. MRP Assumptions

MRP is not without assumptions, and certain criteria must be met for the process to be effective. First, MRP requires that inventory and bill-of-material files be accurate. This is no simple matter when it is considered that inventory levels are frequently inaccurate, and the bill of materials is not even referenced under non-MRP systems. Second, MRP presupposes that lead times for all inventory items are known and fixed. The value of lead time can be changed at any time, but MRP can only operate on one value at a time. Third, MRP assumes that the progression of the manufacturing process from one stage to another will be monitored. Fourth, MRP assumes that all components of an end item must be available at the time of final assembly or in other words, the assembly process is short and the sequence of final assembly is not a factor. A fifth assumption requires discrete disbursement of component materials. Materials that come in continuous form such as rolls of sheet metal require special handling. A final assumption requires process independence or that the manufacture of any end item can be completed without regard to any other end item [3:40].

Violation of several of the above assumptions can be accommodated by MRP by special adaptation. However, these are procedures that will not be addressed here [3:41].

E. MRP SYSTEM DESIGN FACTORS

With a basic understanding of MRP's objectives, limitations, concepts and processing logic, discussion can focus on several practical system design factors that may vary with each MRP application. These factors may or may not be interdependent and are grouped here for convenience.

1. Planning Horizon

One area where MRP and master production schedule design must be approached together is in the determination of the planning horizon. MRP's level-by-level requirements explosion process dictates that the planning horizon be at least equal to the longest cumulative product lead time. Were this not the case, requirements generated for the lowest level items would already be behind schedule. On the other hand, an unnecessarily long planning horizon can also complicate the MRP process for two reasons. First, forecast accuracy may deteriorate with very long planning horizons requiring excess MRP recalculations. Second, multiple end item requirements for the single period will increase system complexity. Although both changes and multiple end-item requirements can and must be accommodated by MRP, minimization of their incidence is desirable [3:158].

2. Time-Buckets

The length of time in incremental periods of the planning horizon is referred to as a time-bucket and is a fundamental design consideration. Determination of the bucket size is influenced by product and manufacturing characteristics. In system design, the period length is a trade-off between the desire to pinpoint events and programming complexity. In most manufacturing operations, a time-bucket of one week is found most practical [4:488]. Once time-bucket increments are identified, the exact point or event scheduled to occur can be fixed by convention [3:73].

3. System Coverage

Traditional inventory control often concentrates on inventory items differently depending on value as in ABC type analysis. As was indicated earlier, this approach to inventory management was derived from an era where the magnitude of data prohibited equal concentration on all items. In manufacturing, the ABC approach has obvious shortcomings, and the computer-assisted technology of MRP makes it unnecessary to exclude inventory items from the system. In manufacturing, a missing low value C item can prohibit assembly. While this can be covered by carrying an unusually large stock of C items, shortages will still exist and the potential benefits of MRP reduced. Therefore, as complete a coverage as possible under the MRP system is desirable [3:161].

4. Lot Sizing

In the discussion of the explosion process and as indicated in Figures 3, 4 and 5, planned order releases were shown to be equal to net calculated requirements. This, clearly, will often be inappropriate for either purchased or manufactured components and subassemblies. Costs of acquisition, costs of holding inventory and economies of scale require balance as in traditional inventory management.

The problem of lot sizing or conversion of MRP net requirements into economically procurable quantities has received a great deal of attention as inventory theory emphasis has shifted with the emergence of MRP systems. Many lot-sizing algorithms have been developed for use by MRP systems. None have been found optimum for all applications, and most MRP systems utilize several lot-sizing algorithms [3:120].

5. Safety Stock

Conceptually, safety stock belongs with those inventory models that assume uniform and continuous demand and relay on aggregate demand data to determine order quantity. MRP does not rely on the above factors. Safety stock where incorporated in MRP is included primarily to compensate for uncertainty of supply. Demand uncertainty is taken up by the master production schedule. Where desirable, however, safety stock can easily be accommodated in an MRP system [3:78].

6. Extraneous Demand for Parts and Components

Although the vast majority of requirements are generated through the master production schedule and the explosion process, MRP must also accommodate the additional demand for parts and components that inevitably occurs. Attrition or scrap rates may and usually are different for different components. Service parts requirements can also be expected. MRP is able to factor these requirements into system calculations [4:494].

7. Regenerative and Net-Change MRP Systems

Regenerative and net-change are the two basic MRP system alternatives. Their difference lies primarily in the type of computer processing technique utilized. The output of both system types is the same.

Schedule regeneration is the conventional approach to MRP. In this system all requirements are exploded in one batch-processing run. As a batch system implies, update is tied to a periodic frequency. Frequency of update of the master production schedule usually drives this system. A weekly or biweekly replanning cycle is typical of regenerative systems. Data-processing efficiency is the primary compra-tive advantage of regenerative systems. The primary disad-vantage is that information is always somewhat out of date as economies seldom allow batch updates more often than weekly [3:99].

If operations dictate frequent replanning, net-change MRP can be employed. With a net-change system, data-processing

capability allows either inventory transactions or master production schedule changes to trigger replanning. Under net-change system access is continuous, outputs are up to date and changes can be processed as they occur. Net-change systems require a greater computer hardware and software investment than do regenerative systems and are rarely found in industry [3:115].

III. OPERATIONAL CONCERNS: A LITERATURE REVIEW

Materials requirements planning has been offered to industry as a process in the new era of inventory management. Computer hardware and software manufacturers promote the system as do many management consulting firms and non-profit professional groups like the American Production and Inventory Control Society.

First actively promoted in the 1960s, there are now thousands of MRP installations nationwide operating in diverse industries such as electronics, food processing and aircraft repair. An increasing desire to improve inventory management effectiveness, the persuasiveness of MRP's logic, the proliferation of computer-assisted management systems throughout industry and the active promotion of the above advocate groups have all contributed to MRP's spread.

With all its promise MRP has not, according to many sources, performed up to expectations. Many companies have found system implementation and operation difficult and according to one recognized industry expert only a small percentage of users are realizing full system benefits [6:62].

Suspected causes of industry's alleged failure to exploit MRP to its fullest have been discussed in the business and logistics management literature. Discussion has usually centered on three themes: start-up problems, operating discipline and information system integration. The purpose

of this chapter is to summarize available information on these subjects. This was used to suggest hypotheses tested in the investigative phase of this research. It also indicated potential areas for further empirical study.

A. START-UP PROBLEMS

A great deal of concern has been paid to problems companies experience during the initial stages of MRP implementation and use. Most difficulties of this type involve making a company's production and inventory control procedures and operation compatible with MRP system technology.

1. Data System Preparation

The structure and content of input data files are primary initial concerns. This involves the master schedule, bill of materials and inventory record files. Failure to structure these files in a manner consistent with MRP technological demands and control over input are often cited as causes of system operational problems. A master schedule that indicates what a company wishes to produce and is not realistic in terms of a company's capability is one specific problem considered prevalent. In order for an MRP system to plan schedules and generate requirements effectively it must start with a master schedule that is both realistic and balanced with a company's capacity [7:27].

A second often-cited problem is improper structuring of the bill of materials. This file is not referenced in conventional inventory control. It is often inaccurate and

may reflect an organization that is not meaningful for inventory management functions. Correcting bill-of-material problems or complete bill restructuring can be a long and complicated process, particularly in a multi-product company with many common components and subassemblies. Companies using a bill of materials in inventory management for the first time may not be aware of the file's shortcomings. In any event, bill-of-material problems are, as reported, often responsible for MRP failure [8:49].

A third problem file and probably the most discussed is the inventory record. Large inventory errors tolerated by conventional systems must be eliminated or MRP introduction will actually reduce inventory system performance. New MRP users find the lack of inventory accuracy a formidable initial obstacle as correction often involves changes in physical facilities as well as new data handling procedures [7:27].

2. Employee Preparation

MRP system complexity requires extensive employee indoctrination and training. Production and inventory control personnel must be thoroughly familiar with system outputs. Training must also be extended to the many employees who generate or input information into the MRP system. Even remotely connected employees must understand how their input is being used to prevent the system from being unconsciously victimized [8:48].

Equally as important as education is wholehearted employee support. Benefits of MRP can be made known to

employees through education. Salesmanship, however, may be required to gain support for the new system particularly when it requires alteration of established procedures. System implementation axioms for training and acceptance success like user involvement and top-management support are also alluded to frequently in the literature [7:29].

B. OPERATING DISCIPLINE

A second major problem area well covered in the literature involves the change in system operating requirements experienced by companies converting to MRP. New demands are placed on employees which must be continually met to insure successful system operation.

1. Records Accuracy

The continuing requirement for a high level of records accuracy is the most troublesome MRP demand. Recognizing the problem and taking corrective action during implementation may provide an initial accuracy level that is acceptable, but maintenance of that standard may be difficult.

In the case of inventory records, a wall-to-wall count and massive location effort can produce an accuracy level of nearly 100 percent, but unless the forces that produced the inaccuracy in the first place are countered, the benefit will soon be lost. For many companies this necessitates rearrangement of physical facilities to provide limited-access storerooms, and for all companies it requires an accuracy consciousness on the part of employees that was not demanded before [9:32].

The same can be said of the bill of materials and other system inputs. Although achieving accuracy of the bill-of-materials file never demands physical plant rearrangement, it requires integration of inventory management and engineering functions and may be difficult to sustain [9:33]. Inputs by purchasing, production and data services personnel also impact MRP and must be accurate to insure effective system operation. The shared responsibility for the maintenance of the system's integrated data base prohibits individual activities from operating autonomously. This complicates an organization's efforts to insure accuracy [6:65].

2. Rapid Change Response

Timely reaction to dynamic business conditions is a stated objective of MRP. The ability to react quickly to changes in sales, delivery dates, product composition and a myriad of other factors that affect manufacturing is an important advantage of MRP over conventional techniques. That same advantage can also cause problems for user companies. The presence of the capability to react to change increases the number of actual changes operating personnel within a company have to deal with. The proper balance between appropriate reaction to changing business conditions and a continually fluctuating organization may be difficult to achieve. System nervousness or changeability is primarily associated with net-change type MRP systems [10:50].

3. Computer System Abdication

A third operating problem that MRP users have to deal with is the tendency that operating personnel may have to surrender their responsibility to the computer system. Employees who do not understand the system or do not want to work with it may do exactly what it indicates without question or ignore it completely [11:79]. The failure to consider MRP a tool that is capable of error can have serious consequences as system monitoring and corrective action is reduced. An influencing factor may be the amount of prior employee experience with computer processed information. This is a consideration when designing employee training programs and failure to gauge this problem accurately can result in system degredation [11:78].

C. INFORMATION SYSTEM INTEGRATION

A third general problem area as reported on in the literature involves the integration of MRP with interfacing information systems. MRP is not a stand-alone system, and effective blending of the process into the general business and manufacturing environment is essential [9:34].

1. Manufacturing System Interface

To be effective MRP must rely on other manufacturing support systems. The importance of inventory record's accuracy was discussed previously. MRP in itself is not a physical control system. For actual inventory control and resulting information MRP depends on the performance of people and other systems.

The same can be said of general manufacturing floor control. Accurate accounting of work-in-process inventories is important to the requirements explosion process. In addition, efficient translation of MRP priority and capacity planning directives into actual manufacturing actions can only be achieved if an effective floor control program exists. These programs constitute MRP's foundation, and the new level of system integration demands a sound basis for the flow of information throughout the manufacturing activity [6:65].

2. Business System Interface

A second major area of the MRP interface problem is in a direction external to the company. The dependent demand principle is useful only if end-product requirements can be accurately forecast within MRP's planning horizon. A forecast that interfaces well with the master production schedule requires that distribution channel and logistics interrelationships be coordinated to achieve that end. Marketing action that is not consistent with MRP timing requirements returns production and inventory control to an expediting mode [9:29].

Another external interface of importance is in the purchasing area. Lead time information for purchased components is a basic MRP input. Mechanisms to control the accuracy of that information must be developed. The tie between effective forecasting, planning and changing lead times is clear. Organizations must have a well-developed and rapid distribution and purchasing communication system to support the coordination effort [5:89].

IV. INVESTIGATION FRAMEWORK

Following background preparation, the major portion of this research was conducted. During the preliminary information search no previous empirical work describing the effects of materials requirements planning on using organizations could be found. Previous writings on the subject, summarized in the past chapter, largely reflect expert opinion and are not directly suitable as a starting point for continuing research.

As a result this study was conducted as initial research with a view toward the identification of MRP and organizational component interrelationships. The purpose of this chapter is to illustrate the conceptual framework under which data were collected, identify and define the hypotheses tested and briefly describe the sources of data used in the analysis.

A. CONCEPTUAL MODEL DESCRIPTION

The input-output model illustrated in Figure 6 was utilized to conceptualize organizations and formed the framework for data collection. The impact of MRP on each organizational element was qualitatively measured. This was possible because of the availability of interview respondents experienced with MRP and non-MRP production and inventory control systems. All but a few respondents performed the same material management functions before and after MRP implementation

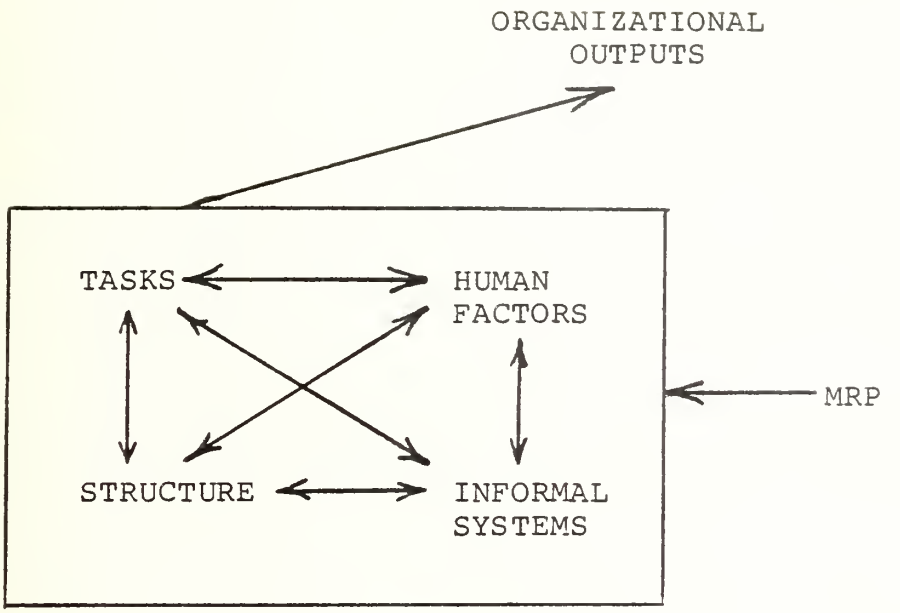


Figure 6. MRP-Organizational Interrelationships

in their companies. Many remain engaged in the same activities.

It was recognized that model elements in turn interact in response to MRP's demands. However, controls for individual organizational elements were not available, and it was not possible to record or analyze resultant changes in element interrelationships.

B. HYPOTHESES IDENTIFICATION AND DEFINITION

The following hypotheses formed the focus of the investigative phase of this research. Due to the considerable potential for subject area overlap, hypotheses are, where required, described in some detail.

1. Hypothesis Number One: Organizational Structure

Hypothesis one stated that MRP has exerted an influence on the structure of the material management functions within a company. Structure was defined as the company's formal organizational arrangement for conducting operations. Changes in departmental or positional responsibilities, regrouping of line and staff relationships, growth or reduction in the size of organizational units, and creation or deletion of organizational units or echelons of management were considered elements of structure in this research.

2. Hypothesis Number Two: Work Content

Hypothesis two stated that MRP has affected the work content of personnel engaged in material management functions. Work content was defined as the quantity and type of tasks employees performed within a particular job category.

3. Hypothesis Number Three: Departmental Interdependence

Hypothesis three stated that MRP has influenced the levels of departmental interdependence within a user company. Intradepartmental and interdepartmental relationships were considered.

4. Hypothesis Number Four: Informal Systems

Hypothesis four stated that MRP has influenced informal operating mechanisms at work within a company. Alterations in informal information flows between employees, changes in work-group dynamics, and changes in power and status levels of material managers were considered elements in this area.

5. Hypothesis Number Five: Employee Displacement

Hypothesis five stated that MRP has been a cause of employee displacement. This question concentrated on the possible changing nature of employees engaged in material management functions in terms of background, aptitude, education and experience. Short and long run effects were considered. Manning level changes resulting from the possible growth or establishment of new functions or the reduction or elimination of old ones, which could result in employee displacement, were considered under organizational structure.

C. DATA SOURCE DESCRIPTIONS

Industrial organizations differ. Differences in size, stage of growth, products, markets and production technology create varying dynamics that impact the organization. MRP is

one of many influences. Although this research did not explicitly deal with the effects of company differences, an effort was made to select data sources with varying characteristics. To provide perspective, brief descriptions of the industrial organizations and functional positions involved in the data collection are provided.

1. Descriptions of Study Locations

The following industrial facilities were represented in the data. Letter designations were used for identification purposes in the chapters that follow.

Facility A. Facility A is a large plant in the grocery products division of a large multi-product corporation. This location is primarily engaged in job-lot production, but some continuous processing of high-volume products is done. Spices and other supplemental food products comprise the product line.

Facility B. Facility B is a large plant in a major corporation in the computer and electronics industry. The study location is engaged in both continuous and job-lot manufacture and assembly of sophisticated electrical instruments.

Facility C. Facility C is a manufacturing activity of a medium sized electronics company. The facility of 215 employees is engaged in job-lot production of radio-receiving and transmitting equipment. A large percentage of production is for custom built requirements.

Facility D. Facility D is a large automotive tire manufacturing plant. It is a division of a major national tire manufacturer engaged in lengthy production runs of various model tires.

Facility E. Facility E is a producer of micro-programming devices using job-lot production techniques. It is a small, single-site company with approximately 150 employees and $10 million in sales.

All facilities studied utilize regenerative MRP systems. Facility D uses MRP to manage only work-in-process inventories. All locations utilize MRP's priority and capacity planning as well as inventory control capabilities.

Except for facility E, study locations are parts of multi-site corporations, and some material management functions are not performed locally. In the context of this study, material management functions include purchasing, production scheduling, material planning, inventory control and required support services.

Facility A's raw material purchases are made at the corporate level, and local purchasing functions primarily involve receipt scheduling and expediting actions. Facility D has a similar arrangement for major raw materials, but some local purchases are made. Only facilities D and E have on-site data-processing capabalities. The remaining study locations utilize centralized corporate computer services. Other material management functions, as narrowly defined above, are under local control. Additional study location specifics

that are associated with a particular hypothesis appear in the discussion and analysis chapter that follows.

2. Position Descriptions of Personnel Interviewed

As was mentioned in the methodology section, initial interviews were conducted with personnel from all five study locations. These interviews were conducted with personnel at the level in the organization that is primarily responsible for material management functions for that activity. Such personnel typically had the title of materials manager and reported directly to the plant's senior operating executive.

Following the initial interviews, facilities A, B and C were selected for further study. At these activities, interviews were then conducted with personnel engaged in production planning and control, material planning, purchasing and material control activities. These functions are briefly described below:

Production Planning--Production planning involves coordination of the assembly or production of the end product. Planners monitor availability of sub-assemblies used in the final production process and initiate schedule changes where required. Production planners may also coordinate and monitor sub-assembly production. The master production schedule is usually produced in this section.

Material Planning--Material planning is very similar to production planning. Material planners monitor the availability of raw materials and purchased parts used in the

manufacturing or production process. If production planning deals only with end items, material planners take over sub-assembly production control responsibilities. Regardless of the exact responsibility division, material planning and production planning are closely related functions.

Purchasing--Purchasing personnel or buyers coordinate the procurement of raw materials and purchased parts used in production. At some locations, purchasing personnel are also responsible for material planning functions. When this is the case, a material planning section does not exist, and production planning monitors both end-item and sub-assembly production.

Material Control--Material control involves material handling, storage and inventory control activities. Management of material storerooms and operation of material location control systems are primary functions. Receiving and sometimes shipping personnel are included in this area.

Non-supervisory operating personnel and all echelons of management up to the material manager level are represented in the data. A limited number of interviews were also conducted with production supervisors, and one interview was conducted with a data systems analyst. Although all data collected were used in the analysis, follow-on interviews at facilities A, B and C accounted for the majority of information acquired. A breakdown of all interviews conducted by organizational level and functional area is provided on the next page.

Organizational Level	Functional Area: Overall Material Management	Production Planning	Purchasing and/or Material Planning (2)	Material Control	Production	Data Services
Non-Supervisory (Level 1)	NA[1]	2	3	1	0	0
1st Level/Ass't Supervisor (Level 2)	NA	NA	1	1	0	0
2nd Level Supervision (Level 3)	NA	3	2	1	1	1
General Function Supervision (Level 4)	4	NA	NA	NA	2	NA

Notes: (1) NA indicates no personnel assigned at that level.
(2) All purchasing personnel interviewed were also material planners.
(3) Total number of personnel interviewed 22. Total number of interviews 30.

Figure 7. Summary of Interviews

V. DISCUSSION AND ANALYSIS

The data collected through interviews with industry personnel were analyzed, and the results are presented in this chapter. The first five major sections of this chapter correspond to the five hypotheses described in Chapter IV. Significant results that do not fit the conceptual model or any study hypothesis are presented in the last section.

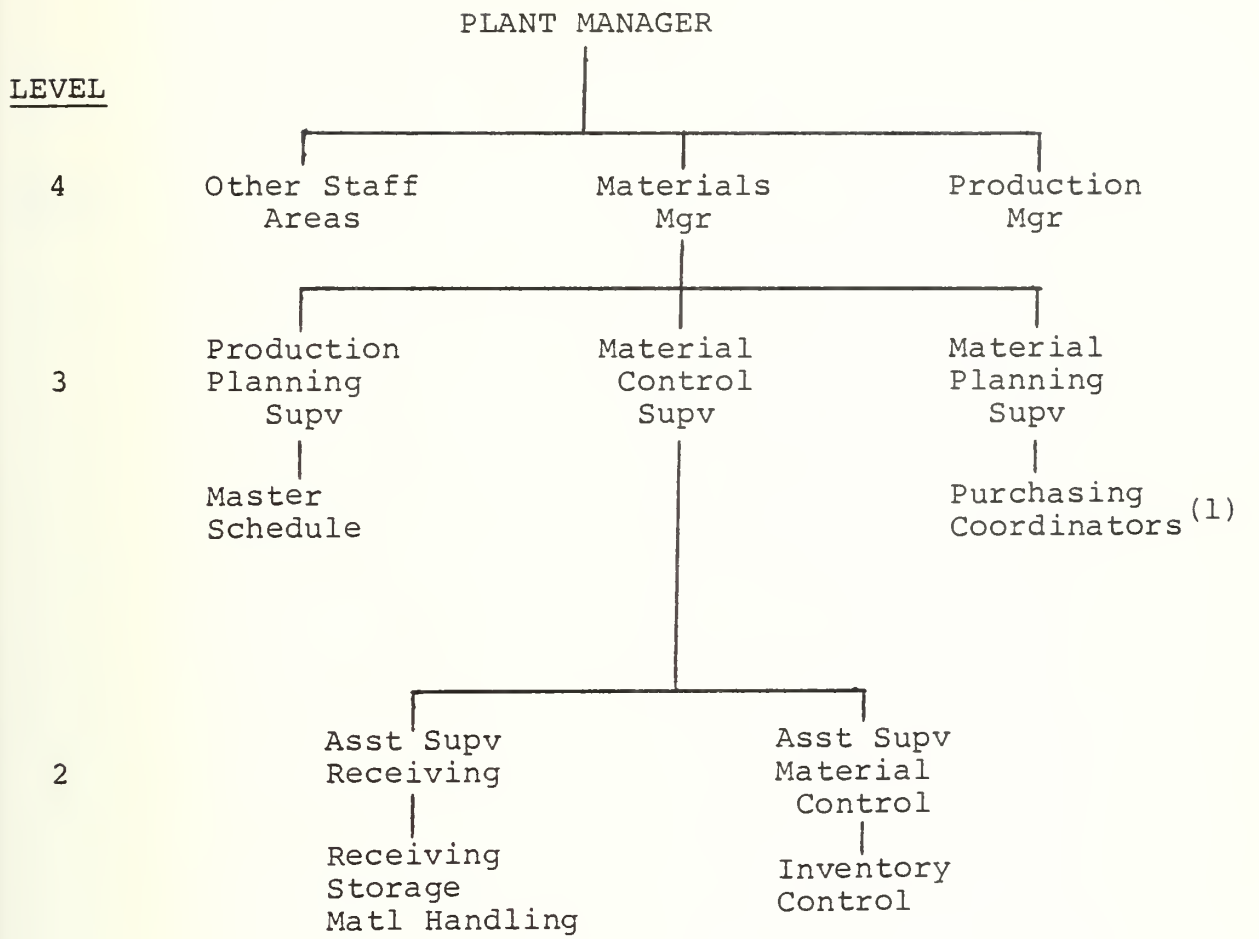
Organizational charts for the five study locations are presented on the pages that follow. Charts were simplified to reflect only material management functions and departmental interfaces addressed in this research. Where organizational titles are not adequately descriptive, major responsibilities are also indicated.

Throughout the analysis summarized opinions of interviewed personnel are presented where possible. This is especially true in the areas of production and material planning which are very similar functions. Major dissenting views or differences due to function are also indicated. Facilities D and E are represented in the data by one interview each. As a result, they are explicitly considered in the analysis only in reference to major structural changes.

A. STRUCTURE

All study locations participated in discussions concerning the effects of MRP on organizational structure. Data

FACILITY A



Note: (1) Receipt scheduling functions only.

Figure 8. Facility Organization Chart

FACILITY B

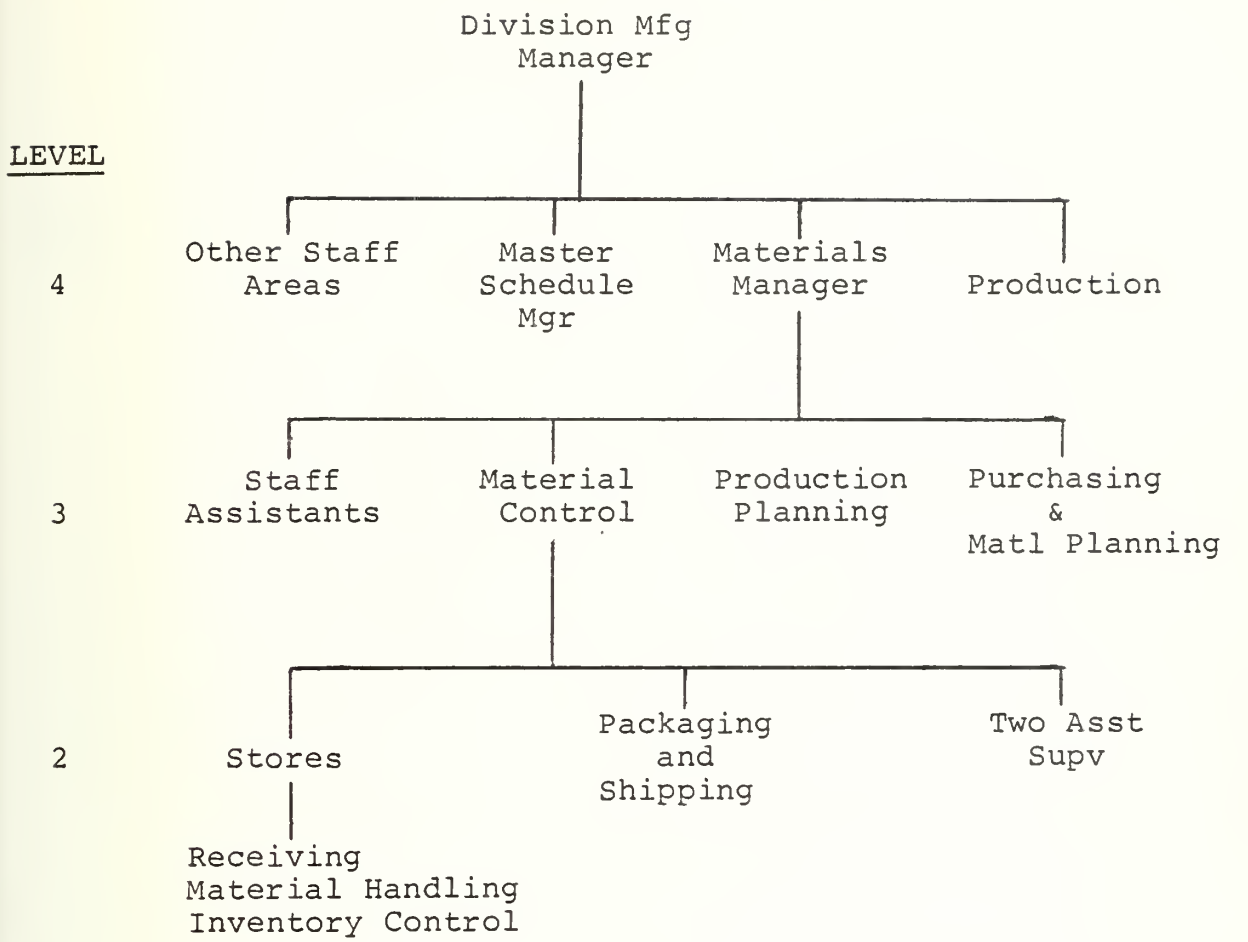


Figure 9. Facility B Organization Chart

FACILITY C

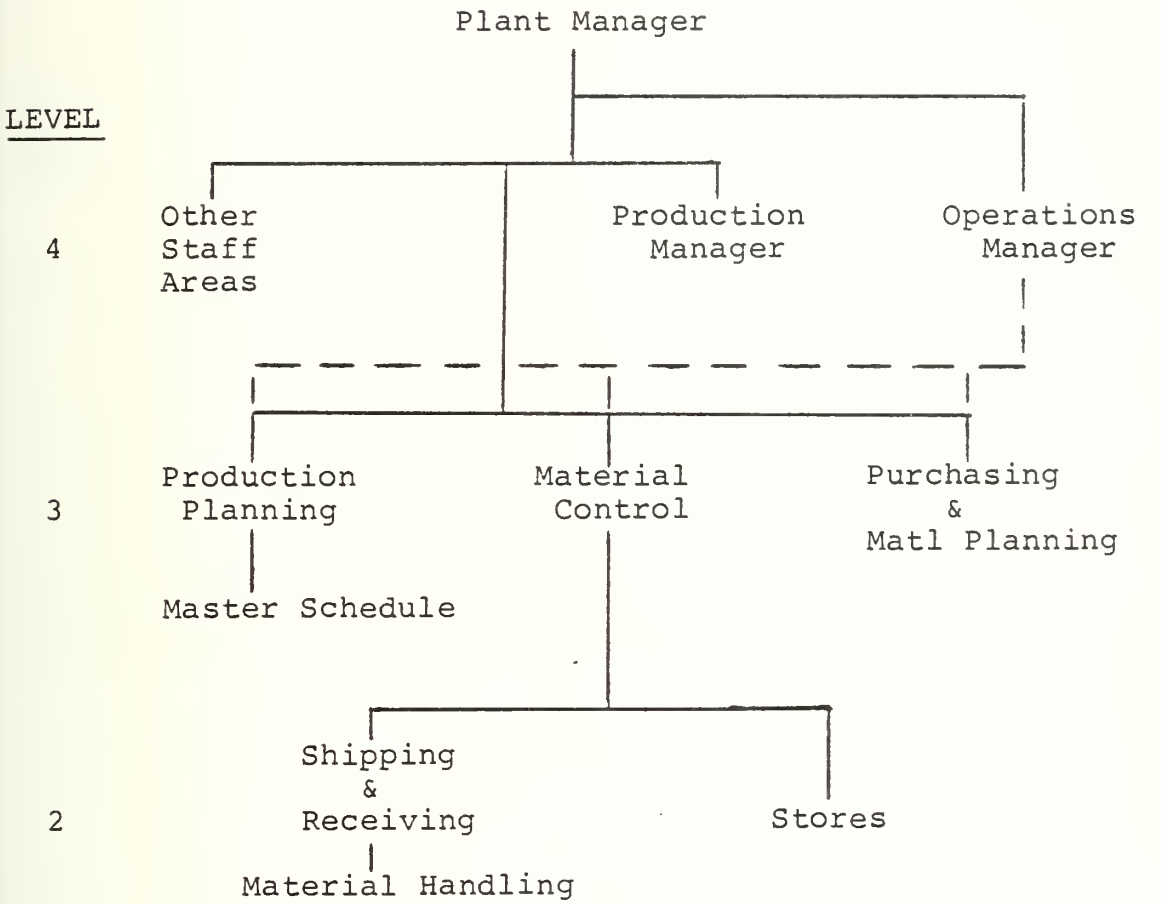


Figure 10. Facility C Organization Chart

FACILITY D

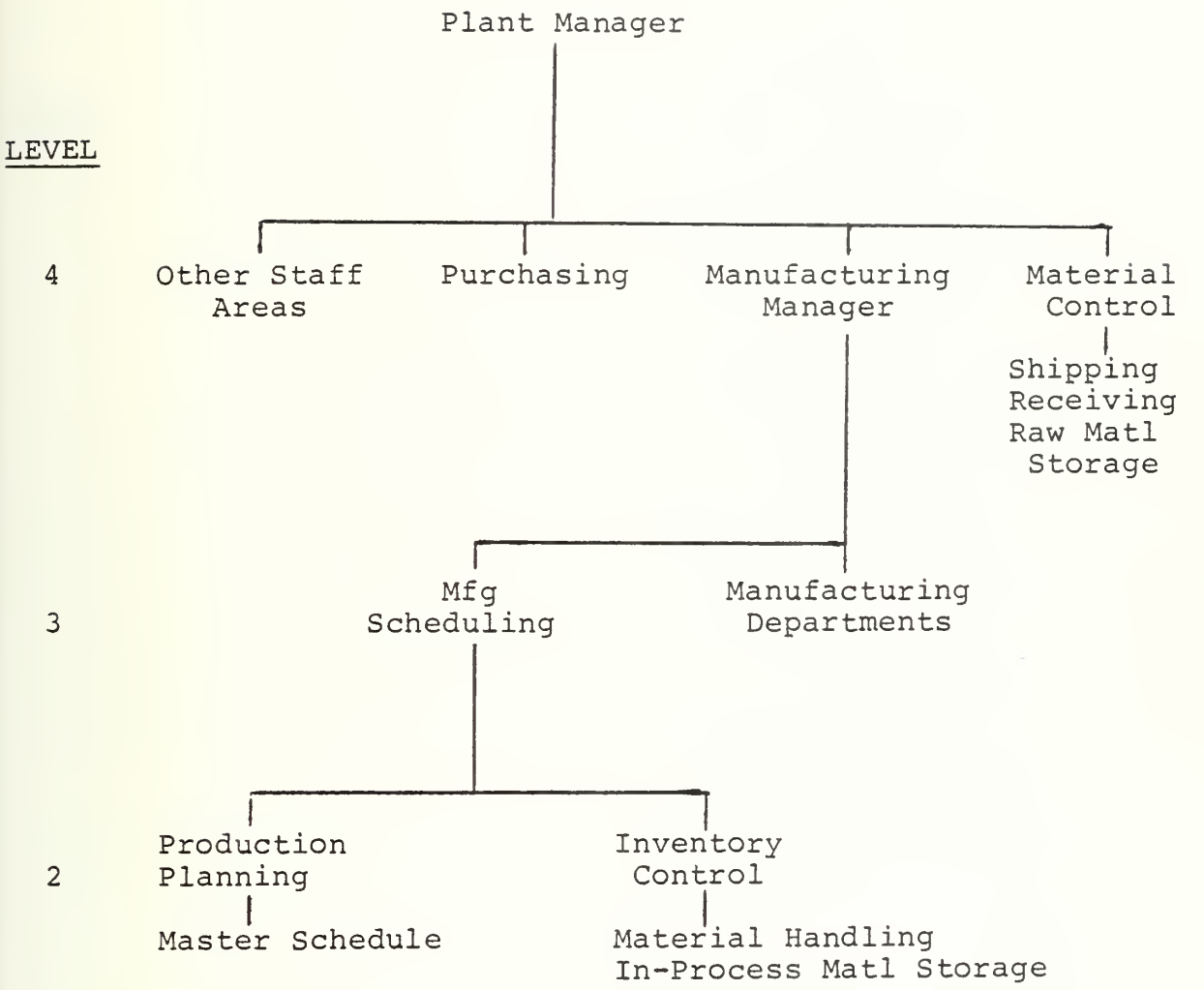


Figure 11. Facility D Organization Chart

FACILITY E

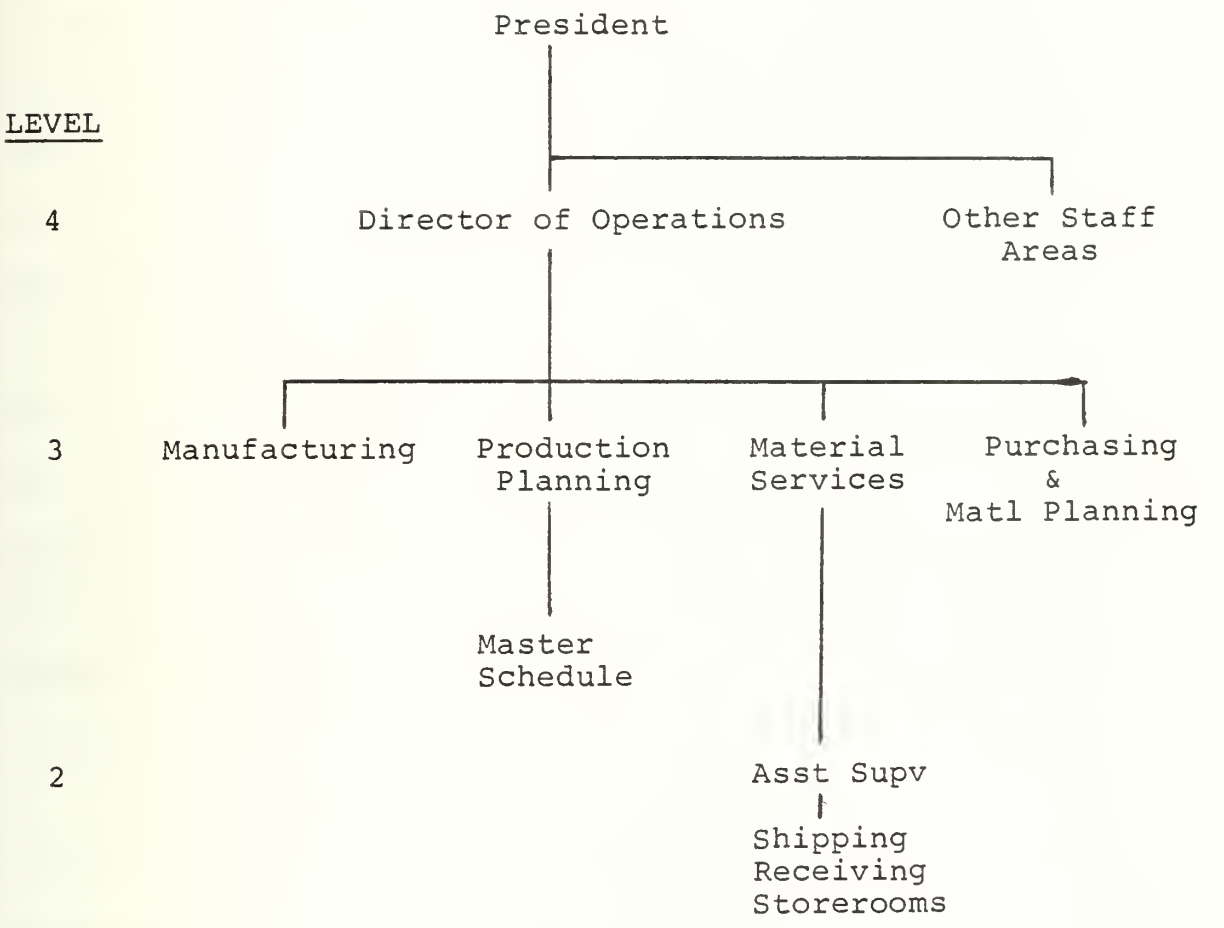


Figure 12. Facility E Organization Chart

analysis revealed that MRP impacts relative to structure are divided into three categories as discussed below.

1. Major Changes in Structural Relationships

The first question addressed during discussions with industry personnel concerned the arrangement of major material management functions within the organization. Facilities A and B exhibit a structure reflective of the material manager concept with all material management functions reporting to the senior operating executive via one department head. Facility C has an organization very close to the material manager model. Formally personnel responsible for material handling and control, purchasing and production planning report directly to the plant manager. The operations manager, organizationally a senior executive assistant, routinely acts in a material manager role in coordinating material functions. Facilities D and E have different structures as discussed later in this section.

Facility A and B material managers both indicated during interviews that successful MRP operation required that purchasing, production and material planning, inventory control and material handling functions all report to a single department head. Improved coordination of the interdependent activities was given as the primary reason:

> Inventory control functions must report to one person who can coordinate activities. [12]
>
> The organization has to be this way because I [Materials Manager] have to make all the pieces fit. [13]

Subordinate personnel at all levels shared this view. It was noted, however, that the material manager concept was in place in both locations prior to computerized MRP implementation, and major structural changes did not occur. Both companies had utilized for many years a manual production and inventory control system based on the dependent-demand principle and MRP timing philosophies which required a similar arrangement of material management functions.

Concerning consolidation of inventory functions, facility C's operations manager expressed a view similar to the view of facility A and B personnel. However, this opinion was not shared by subordinates who considered the added management echelon an unnecessary communication block and counterproductive in the conduct of the daily routine. The operations manager was looked to as an authority substitute for the plant manager, who was frequently absent, and not as an intermediate management level. Like facilities A and B, company D, which operated an order-point inventory control system prior to MRP, did not alter the basic structure of material management functions as a result of MRP implementation. Company size may have been a factor for this study location.

Facility D's structure reflects their operation. Responsibility for production and raw-material inventory control is divided. The scheduling manager, the senior company official interviewed, is responsible for production planning and control of work-in-process inventories. As discussed in the previous chapter, MRP at this facility is only used for

in-process control. Raw-material inventory control utilizes order-point techniques which are much less dependent on manufacturing information than MRP. As a result, consolidation of the different inventory control functions was not required.

The structure of facility E is probably a direct result of its size. The director of operations also alluded to the importance of having all material management functions grouped under the same head. However, in a small company, the director of operations was able to perform the required coordination function.

Taken in the aggregate, statements of industry personnel indicated that consolidation of material management functions under a single manager was desirable when utilizing MRP. For whatever reason, however, the study locations did not experience a major structural change during or after the transition to materials requirements planning. A possible explanation for this, in addition to those offered above, is presented in a later section.

2. Moderate Changes in Structural Relationships

Although major structural reorganizations were not recorded, several significant changes in responsibility were experienced by study locations. One change involved work-in-process inventories. All three facilities found it necessary to create limited-access work-in-process storerooms. This change shifted inventory control responsibility for semi-finished but temporarily inactive materials from production to the material control section. This was necessary due to

the inability of production departments to maintain accuracy of work-in-process inventory counts used as an input to the MRP explosion process. Personnel from production and material management groups agreed with this change. Material management personnel at all levels credited production's failure in this area to a lack of motivation to maintain accuracy and inadequate training of production employees:

> The in-process counts were a mess. The production people just didn't care about it. [13]
>
> We [material planning] had a lot problems from production keeping the in process accurate. Training is a big problem. [12]

Level three and four production personnel interviewed blamed the accuracy problem on frequent employee turnover and more than one employee involved in any single material transaction. A lack of productive-employee motivation to comply with paperwork requirements of the control system was also cited:

> It's hard to maintain control with personnel turnover every two weeks. [12]
>
> In any one transaction, we [production] could have several people in on it. [12]
>
> Additional paperwork. It's hard to get production people to pay attention to it. [13]

Establishment of in-process storerooms at facilities B and C eliminated formal inventory input responsibilities for manufacturing personnel at these activities. Facility A continues to include some in-process material under production control as an input to the explosion process. In an effort to

insure inventory accuracy of this material, facility A has created a production position that as much as possible is singularly responsible for each department's material transactions and related documentation. This step has helped, but in-process inventory accuracy remains a problem for that activity.

Another structural change recorded only at facility B involved shifting the master schedule function from the material management area to production. Two basic reasons were offered for this change. First, production personnel considered the shift necessary to improve consolidation of marketing and manufacturing capacity information in producing the master schedule. Material management's production control personnel agreed with production's assessment:

> When the master schedule was located in materials, we were in the middle between manufacturing and marketing and didn't have any real expertise in either side of the master schedule question --forecasting and capacity. [13]

Other material management personnel suggested that prior to the shift production personnel overstated plant capacity as an input to the master schedule in an effort to increase general inventory levels and improve productive flexibility. Statements by a level four production supervisor tended to corroborate that charge:

> We [production] should beef up the master schedule a little to make sure we have some material available to cover shortages that come up in other areas. If I schedule exactly what I think I can produce and some shortages come up, then we've no ability to substitute other things. [13]

The manufacturing manager's support of MRP and desire to produce a realistic master schedule in support of the process was the reason suggested for the success of the change.

The time since MRP implementation in the study locations varied from a few months to seven years. Structural changes in response to inventory accuracy problems are most likely to occur soon after implementation. Other structural changes do not appear to be sensitive to the time elapsed since MRP introduction.

3. Growth or Reduction of Functional Areas

Personnel at all levels were questioned regarding the effect of MRP on manning levels within material management functional areas. Responses to this question were complicated by the fact that all study locations have experienced major productive expansions during the years following MRP implementation. However, personnel interviewed indicated that MRP taken alone caused a slight decrease in the number of material management personnel engaged in the clerical aspects of material and production planning.

Discussions further indicated, however, that the above reduction was offset by an increase in the number of personnel engaged in actual material handling and control functions in spite of the reduced handling of material resulting from a lower general inventory level. Establishment of perpetual inventory systems like cycle counting and increased location and record monitoring by receiving and storage personnel were responsible for the increase. All level

four personnel interviewed considered that MRP has caused a net increase in personnel engaged in production and inventory control functions. The magnitude of the increase, however, could not be determined due to the business expansion factor stated earlier.

B. WORK CONTENT

Recorded effects of MRP on people relative to their jobs varied depending on organizational level and function performed. In the treatment that follows, effects of MRP on material managers are categoriezed according to level while differences due to function are indicated in the discussion.

1. Material Management Personnel at Level Four

The major MRP impact on the work content of material managers at this level involves the coordination of the various production and inventory control functions to achieve MRP system effectiveness. Level four material managers at follow-on study locations all considered MRP to be an excellent tool providing for an improved degree of visibility and control over material management activities. Managers had confidence in the capability of MRP to provide an efficient material management plan and were under pressure from general management to use the system. Their primary concern was to insure that information that provided the basis for that plan was correct:

> I [material manager] know what questions to ask. I can keep a better handle on things, but the information that comes out is only as good as what goes in. [13]

> MRP really does work. It demands a lot of management to keep the plan right, but it does get things to where they are needed. [12]

> MRP requires a lot of monitoring, and my job's [material manager's] emphasis has swung a little in that direction. [13]

A second level four impact associated with system accuracy is an increased requirement for training. Material managers expressed a need for understanding all aspects of the process and for ensuring that subordinates had the same information.

> MRP has added a new dimension to a material manager's knowledge requirements. Lower levels in the department have the same requirement. [13]

> Keeping your people up to speed is hard. If we [material management in general] slack off, we have problems--especially if we have turnover. [12]

Level four material managers also believed they were being held more accountable for the success of their company's inventory policy and were required to react to more frequent marketing changes. The addition of MRP as a management tool was cited as a reason in both cases.

2. Material Management Personnel at Levels Two and Three

Many of the sentiments expressed at levels two and three regarding MRP work-content impacts paralleled comments of personnel at level four. Like their superiors, level three managers and their assistants considered that MRP offered a tool that improved their capability to effectively manage material resources. They considered their jobs to be much more focused regarding attainment of specific goals and expected to be held accountable for improved results:

> MRP collates information for you. I [purchasing supervisor] know what is important and can plan better. With better tools you should expect better performance--from me and my buyers. [14]

> Before MRP, information was difficult to get a handle on. Production had their own gut feel and often did what they thought best. A lot of time they were right. With MRP, production control can do a better job. [13]

To this level of supervision, however, fell the chief responsibility for MRP system maintenance and use, and they were more sensitive of the difficulty of these tasks than were level four managers. In every functional area, level two and three managers stressed the need to continually monitor the system for accuracy and subordinates for proper use of MRP outputs. Managers cited the difficulty of recognizing errors and taking appropriate steps to correct not only the computer-suggested action but also the data basis for the incorrect system suggestion as MRP's most demanding operational characteristic. Analysis of computer-processed information and the identification of potential errors in MRP reports are difficult tasks. Managers emphasized their training requirement. They considered the development in subordinates of the ability to properly use and maintain the system to be their central responsibility:

> Analytical ability in production control is important to maintaining the data base. We want our people to deviate from the plan when they recognize an error, but it's important to go back and find out why the report was wrong and correct it. [13]

> You [material planning] must have people who can use judgment, analyze and spot mistakes and then make the required corrections. It's hard to

develop that in people, but you have to continually work to make sure they use the system properly. [12]

Level two and three managers recognized that MRP disseminates production and inventory control information throughout the organization. They are less relied upon to provide superiors status information as a result. The monitoring function, however, is so great that it has compensated for that loss in demand for their services.

3. Material Management Level One Operating Personnel

The most pronounced changes in work content resulting from MRP implementation have occured at this level. The most immediate impact was the great reduction in the clerical aspects of material and production planning and purchasing functions especially in facilities A and B where manual MRP-like systems had been used previously. The computer relieved operating personnel of the task of painstaking calculation of a multitude of material requirements. It also provided employees involved in scheduling functions with a series of system reports that suggested manufacturing or purchasing actions.

Although MRP systems differed, each company's system provided both comprehensive and exception reports that kept track of routine business and identified problem areas. As a result of the labor savings, planners had a greater portion of their time available for attending to problems. Added activities included the validation of material availability

prior to initiating production action and the increase in liaison with vendors:

> We [material planning] didn't have time to investigate things like we do now. We had enough problems making all the calculations. If a lot of changes came through, we were dead. [12]

> We [production planning] now do a lot of pre-expediting to make sure material is available for production when the start date comes. [13]

> Every Monday I [buyer] get my report. I go through each item and make a list of things I need to order or follow up on. [14]

The effective use of MRP's improved capability to assist in inventory management has requirements and places many demands on operating personnel. Of central importance is the requirement that personnel engaged in material management functions be more knowledgeable of the company's products, manufacturing processes and the MRP system. This is required in support of system monitoring and the prevention of unconscious system sabotage. Effective monitoring or problem analysis can occur only if personnel have a supporting in-depth familiarity with the entire material requirements generation process.

MRP is precise and it takes future occurrences like planned receipts or firm production orders into account when generating additional requirements. The timing and accuracy of futuristic information are as important to the system as the correct recording of received material. Many occurrences can introduce problems. For example:

- A low-percentage option item that is erroneously applied to the entire product line may generate a large and incorrect procurement action.

- If a production yield falls one item short at 99 and the system's lot-sizing algorithm calls for production runs of 100, MRP will generate a new requirement for 100 items together with supporting materials to cover the single-item shortage.

- If a production run is reported completed on Friday and the corresponding in-process material deletion is not reported until Monday, then Monday's weekly report will understate future material requirements by the amount of the in-process quantity.

Situations like those described above are by no means isolated, and system responses are often inappropriate. The ability of planners to manage this aspect of MRP depends directly on their complete understanding of interacting system elements. All personnel levels considered the complete system knowledge requirement to be the key factor in successful system operation:

> The complexity of it all. My [material planning] people really have to understand the product and MRP and how all the pieces fit together. [12]

> It takes a long time to learn how to use all the reports. We [production planning] have some new people who haven't been too successful. [13]

> You [material management in general] have to have some knowledge and experience. You have to backtrack on problems to straighten MRP out and keep it accurate. [13]

Not all operational-level employees are proficient to the degree required to maintain MRP system integrity. In addition, it is possible for knowledgeable scheduling or procurement personnel to make manual alterations to system suggestions, to take action based on the revised information and then to fail to research and correct the erroneous system output. The aversion operating personnel may have to spending a good deal of effort trying to make the computer's answer match the answer they have calculated manually is understandable. Equally as apparent are the potentially catastrophic system consequences that may eventually result if system maintenance is not rigorously pursued. This problem has been recognized by material managers and, as a result, operating personnel are partially evaluated on how well they maintain the data base. It is an easy matter to compare actual procurement or planning actions with corresponding system suggestions. With this input, personnel evaluations have become much more quantitative:

> People [material managers in general] are evaluated formally on how well they manage their data base. How well they use the tool as well as results count. [13]
>
> This helps insure accuracy of the system. Their evaluations are tied to hard numbers, and it's easy to measure how well they are doing. [13]
>
> You have to watch it, or bad numbers can become the rule. [14]

Another impact at this level involved the pace or activity level of material management positions. Prior to MRP, material functions demanded an almost harried activity

level. Manual determination of production or material requirements incorporated a combination of calculations, phone calls, personal checking of inventory levels and a synthesis of information from a variety of other sources.

With MRP, however, the required information arrives at the planner's desk in a well-organized ready-to-use format. As described previously, the performance demands remain great, but the sedate analytical reviewing of an inch-thick computer report is quite different from the often frenzied jobs of the past.

One material planning supervisor feared that this aspect of MRP could eventually undermine system integrity. Planning personnel were rotated in order to break up the monotony of reviewing the same reports and to maintain employee interest:

> People get bored with computer reports. You need to do a lot more cross-training to prevent it. Once boredom sets in, real system monitoring ceases. [12]

Employees seemed to agree with the job rotation program. They believed that cross-training in general was an asset and agreed that boredom could produce computer abdication. Personnel at all levels recognized MRP's computer-abdication potential, but the problem was generally considered to be under control.

The impacts described in the past few pages principally apply to personnel engaged in material planning, production planning and purchasing functions who constitute the

actual users of MRP reports. Personnel engaged in inventory control, material handling and storage functions are for the most part involved with MRP on the input side. For these personnel MRP's principal demand is inventory accuracy. Establishment of more sophisticated location and inventory control support systems has paralleled the demand for increased accuracy.

Inventory control personnel are frequently called on to reconcile conflicting material records and investigate suspected errors uncovered by planners or production personnel. Routine audit checks of inventory records are part of the control system. Errors are traced back to their cause to facilitate evaluation of material handling and storage personnel and correction of poor inventory practices:

> Basically we [inventory control personnel] are auditors. We make error checks on a regular schedule. We evaluate the movers to provide feedback on how well they are doing as far as accuracy is concerned. [12]

Investigations of inventory problems frequently entail analysis of MRP reports, and inventory personnel are also required to understand the MRP process. Although the system knowledge requirement is not as great as it is for planners, inventory control personnel describe their jobs as much more systematic than in the past reflecting the addition of MRP and required support systems.

C. INTERDEPENDENCE

Some of the effects of MRP on department and division interdependence levels within an organization have been discussed previously. In this section, a more complete description of MRP impacts on interdependence recorded during this study is presented.

1. Material Management-Production Interdependence

Interdepartmental cooperation between production and material management functions has always been required. MRP, however, has caused the two areas to interact more often.

The importance of work-in-process inventory accuracy to the requirements-explosion process has already been discussed. Production can, however, influence inventory in other ways as well. For example:

- The unscheduled use of common components to utilize idle capacity in one area can cause a material shortage in another with the production of unneeded subassemblies at the possible expense of a planned requirement the net result.

- The diversion of a high-grade material to cover a shortage in a lower quality requirement may avoid an impending work stoppage but may not be in the best overall interests of the production plan.

- Unreported changes in a production yield can increase material consumption and cause future shortages.

Any of the above activities can cause a future production plan to fail due to inventory shortages, and study location personnel reported occurrences of all three situations.

The same problems could exist regardless of the type of production and inventory control systems used. Shortages due to the above conditions will increase, however, with an MRP system. This is due to MRP-induced inventory reductions and the attempt to match material with products on the production schedule. Material management personnel considered this a major problem:

> I [material planner] code all material so production knows what to use it for. It's up to production to follow the codes. They don't always follow the codes. If something isn't there, they'll take whatever is available. [12]

> If they [production] get a little ahead, they may run something that's not on the schedule and draw extra parts to do it. Then you [purchasing] may be in trouble somewhere else. [13]

A second area of manufacturing-materials management interdependence involves the knowledge requirement of personnel engaged in planning functions. Planning supervisors have discovered an increasing need to insure effective communication between production and material planning coordinators and the production supervisors of the areas they deal with. Few planning personnel have manufacturing familiarity to the degree required to effectively support the total system knowledge demanded by MRP. Close cooperation between planners and production supervisors has been identified as a way to offset the manufacturing knowledge deficiency found to exist in many production and material planning personnel. To facilitate a cooperative effort, facility B has realigned planning responsibilities along a process orientation. Planning responsibilities had previously been along product lines.

This change created a material management organization that was somewhat similar to the process responsibility division in production areas. This provided for more one-on-one contact between production and material management personnel in the hopes of improving communication:

> We [production planning] are dividing up products among production planners according to process types in order to accommodate the one-on-one plan. Before a production supervisor would have to deal with several planners. [13]

Manning level differences, however, often require planners to be responsible for more than one process.

This arrangement of planning responsibility presents an interesting dilemma. MRP users indicate that product knowledge is also an important element. Division of planning responsibility along product lines fostered education in the product area. The shift to process responsibility requires that material managers now deal with only pieces of many products. The increase in a material manager's manufacturing expertise and more effective production-material management communication may be at the expense of product knowledge erosion. Material planners at facility C expressed the reality of this concern. Like facility A, facility C has always used the process alignment. A facility B planner also expressed apprehension about the new system:

> Planners are a long way from the product and are hampered by product unfamiliarity. [14]

> I [production planner] think it will be a problem because no one has an entire product. People won't learn the little things about their product. [13]

Possibly the greatest influence MRP exerts on the degree of mutual dependence existing between materials management and production stems from the proposition that MRP is a highly visible program that required a sizeable company investment. All level four material managers stated that they were under top-management pressure to produce a workable plan. Production managers expressed a similar requirement to follow the plan. This has fostered cooperation between the two groups in spite of the fact that MRP brings several of the traditional conflicts into sharp focus:

> We [material management] are told to make the plan right, and production is told to follow it. Neither can happen unless we work together on it. [12]

> The plan has top-management support. We [production] need to follow it the best we can. [12]

Production personnel, although having some criticisms, generally considered MRP to be an effective control system. This undoubtedly has been an important factor in maintaining the production-materials management cooperation required to operate the system.

2. Material Management Functional Area Interdependence

Purchasing, raw material planning, production planning and inventory control are also interdependent functions. Like the production-material management interdependence discussed in the previous section, the mutual dependence of material management functions has always existed. However, intra-material management relationships relative to changes induced by MRP are even more a matter of degree than the

factors discussed earlier. There are, however, identifiable characteristics of MRP that have influenced the relationships existing between material management functions.

One area of dependence results from the common source of all planning activities. Purchasing and material planning functions are driven by the master schedule. Production planning that deviates from the master schedule results in insufficient or excess material support. Manual or off-line addition of independent service-parts demand by production control without formal system introduction is an example of the type of activity that can cause material shortages. Manual increaes in production orders to compensate for possible production yield fluctuations can have the same result. Both problems were reported by study location personnel and cited as causes of increased communication between the various functions.

The precise nature of MRP and the realization by material managers that manufacturing or business reality is not as precise is another source of functional interdependence. Manufacturing and procurement lead times, order quantities, production requirements and lot sizes are all fixed MRP system elements. Frequent compromise of those elements and the desire to satisfy production requirements requires the cooperation of several interests:

> We [production control] juggle lead times with purchasing and production to get the schedule completed. Lead times have a little extra so we negotiate before we actually change plans. [13]

> Receiving has a hot sheet, and they call me [material planning] when material is received. We watch it until we get to a decision point and then reschedule if necessary. [12]

> I [production control] never used to even talk to purchasing. Now I talk to them all the time to see if they can beat a lead time if I need it. [13]

Personnel stressed teamwork, cooperation and the knowledge that scheduling functions cannot go on independently as essential to MRP operation.

More than any other element, the demand for system accuracy intensifies interdependence and requires cooperation. All study-locations utilized regenerative MRP systems with weekly updates. System errors may impact several material management sections. Depending on timing, errors detected by one section and corrected formally without simultaneous verbal or written notification of other affected personnel may result in unnecessary and avoidable production or procurement actions. Study locations reported that problems of this type were common and difficult to correct:

> Manual systems had more slop. You [material management in general] could be wrong more often without causing problems. It's hard to get people out of that can have errors mentality. [13]

> If they [storage] find an error and don't tell us [purchasing], we don't find out until the next week when we get the new printout. It happens a lot, and I get irate about it, especially for long lead-time items. [14]

Study location personnel cited the tendency of people not to discuss mistakes that they have caused, the belief that the system will make the necessary corrections, and the

failure to understand the ramifications of errors as factors contributing to the accuracy problem. Frequently referenced as the underlying cause of all three conditions was inadequate personnel training.

D. INFORMAL SYSTEMS

The collection of data by an observer external to the study locations precluded measurement to any degree of MRP impacts on informal operating mechanisms. Those effects that were observed, however, are presented in this section.

1. Formalization of the System

Formalization of procedures was a stated objective of all material management supervisors interviewed. Procedures formalized included verbal and written information flows between and within departments, performance rules for each job category, and procedures for the actual handling, storage and issuance of manufacturing materials. The precision with which MRP must operate and the requirement to backtrack and resolve system errors justified a rigidly formal system:

> Relationships have been formalized. It has to be that way. People have to follow the rules and you [material management] have got to monitor continuously to insure that informal systems don't develop. [12]

> MRP needs a more formal and rigid operation. If something doesn't work, people fall back on what does. You [material management supervision] have to keep an eye out for that. If something informal has developed, it's a sign that the system has a problem and usually it's a data base maintenance problem. [13]

Level one operating personnel generally agreed that the system was extremely structured. Informal working arrangements, where found to be necessary, were incorporated into company procedure. Personnel also pointed out, however, that the magnitude of the required cooperative effort precluded complete reduction of all communication to a structured format.

2. Perceived Importance of Material Management Positions

The past sections have indicated that materials requirements planning has altered the type of work performed by personnel engaged in material management functions. The nature of communications and the degree of interdependence between subordinates and supervisors, between contemporaries and between personnel in different departments and divisions have also changed. These changes have influenced the opinions of personnel about their own jobs and about other material management positions.

Level four material managers generally believed that their jobs had increased in importance during the years since MRP implementation. They pointed out, however, that the increase has paralleled the general increase in attention that inventory management has received in industry:

> The materials management area in general has been upgraded--not necessarily resulting from MRP. [13]

> The materials manager is one of the two top departments in the company--production being the other. But that's not just due to MRP. [12]

Level four material managers did see their jobs as more professional after MRP. They indicated an increased involvement with keeping up with developments in material management techniques as related in the professional literature. All but one were members of a professional production and inventory management society.

Level three material managers and below viewed MRP as having a more direct influence on the importance of their positions than did managers at level four. Level three managers and their level two assistants credited MRP's critical monitoring requirement with increasing the importance of their positions. They also considered their jobs more management oriented than in the past:

> MRP requires a lot of management to make it work. Jobs like this [material control supervisor] were upgraded considerably over what they were. [12]

> Once the information is correct and everybody meets their required dates, then it all runs smoothly. That's were we [planning supervisors] come in. Management of this system is very important. [13]

Level one positions were altered the most by MRP. The opinions of level one personnel of the functions they perform are consistent with the job-content changes discussed previously. The jobs were reported easier regarding the volume of work required. The more analytical and less clerical aspects of their positions, however, required greater versatility, knowledge and judgment on their parts:

> The jobs are less work now. It took some skill to figure out things before, but I [production planner] think you need to be a better planner to use MRP. [13]

> I [material planner] feel that I'm more needed now than I was under the old system. You really have to work at this system. You need competent people, and I'm proud of my contribution. [12]

Relative to job status and importance, one category of level one employee stood out. Facilities A and B each had at least one production or material planner that had performed largely the same function under the manual MRP-like system described earlier. The manual system entailed part-by-part explosion of material requirements. The manual explosion process developed in planners a great familiarity with the company's products, manufacturing processes and MRP concepts. The background knowledge was augmented with years of computerized MRP experience. This created an employee with a much greater capability to manage MRP than planners without the manual system experience. Personnel were convinced that the combination of old and new system experience was instrumental in their success. Employees with the dual system experience were highly respected for their skill, depended on by contemporaries for job assistance and heavily involved in department training programs. This situation was not observed at facility C which did not use an MRP-like system previously.

Top-down assessments of material management positions generally corresponded with the viewpoints expressed at each level. Comments of personnel regarding their view of their supervisor's jobs were not solicited. However, those comments of subordinates that were offered were consistent with the

level-by-level analysis presented. Opinions of non-material management personnel were not recorded.

E. EMPLOYEE DISPLACEMENT

MRP induced many changes in the study locations. The degree to which these changes were responsible for employee displacement is discussed in this section. Manning level changes were presented in the discussion on structure.

1. Material Handling and Inventory Control Personnel

The most immediate and recognizable personnel change resulting from MRP introduction occurred in the material control area. Facilities A and C both reported an almost immediate upgrading of personnel engaged in inventory control and material handling and storage functions. Upgrading was a direct result of the requirement for increased operating discipline and the necessity to use and understand MRP and support-system reports:

> We [materials management] upgraded the quality of stores personnel. They have to be able to understand MRP reports so they don't goof it up. Pay scales for these people are much higher than for that type of employee in general. [14]

> Inventory people have to be different than they were before. They need a good math aptitude and ability and desire to learn the MRP system. We [material control management] offer higher pay and steadier employment and make selection of an inventory job competitive. [12]

Almost immediate personnel changes in this area at facilities A and C were possible because of the manning level growth that resulted from the addition of inventory control functions like cycle counting and increased inventory

location control. Facility B did not attempt to upgrade inventory control positions, and managers indicated that failure to do so may be responsible for accuracy problems.

2. Material Management Planning Personnel

Level three and four material managers expressed the need to recruit personnel with backgrounds suited to the changed demands of material and production planning positions. Credentials identified by supervision as desirable were college degrees, analytical ability, business perspectives and experience with computerized information systems:

> There hasn't been any short-run displacement in production control, but in the long run the emphasis is on hiring college graduates with a sense of inventory value and the ability to work with the MRP system. [13]

> No one left just because of MRP. We [material planning] are careful when we take on new people and try to hire those that will work well with the system. Analytical ability is important with some systems background. [12]

No facility reported short-run displacement of planning personnel as a direct result of MRP implementation. Non-supervisory personnel verified this claim by management. Personnel reductions alluded to previously were accomplished by attrition. New personnel hired have, according to supervision, fit the new criteria.

Material planning supervisors at study locations are, with few exceptions, long-term employees. All level four managers had previously held subordinate material management positions. Managers at levels two and three were either

promoted from a level one position or were transferred from another department, mainly production. Although no supervisory-level displacement was recorded, managers generally considered logistics management and computer information systems education and background to be essential credentials for material managers of the future.

F. OTHER FINDINGS

The model utilized to conceptualize the organization during the data-collection and analysis phases of this research was necessarily too macro or abstract in nature. As a result, data were collected that did not describe the model or any of the study hypotheses. The most significant and re-occurring of the non-model impacts are presented in this section.

1. MRP System Consolidation

Two of the three follow-on study locations are divisions of large corporations that have similar divisions. The data processing activities that support each location's MRP operation are centralized and under direct corporate control. Facilities A and B both reported a corporate desire to standardize MRP computer software used by similar divisions. This step was designed as a data-processing efficiency measure. For each study location standardization resulted in changes in MRP input documentation, output report formats and content and production control procedures.

Many of these changes were unpopular with both material management and production personnel. Also cited as part

of the problem was the difficulty in making desired changes:

> Every time we [material management] want a change we need a majority vote [of the divisions]. We had a better system when we had complete control. [13]

> We [material planning] used to have a better system. Before our system was consolidated with the east coast, we had a way to reserve material for certain uses. [12]

Facility A reported that problems of the type indicated above were especially severe. Material managers at all levels credited software standardization with a large percentage of MRP operational problems experienced at that facility.

2. Changing Business Conditions

A second reported condition directly attacked the simplicity of the conceptual model. Level four managers especially reported that many of the impacts attributed to MRP may have occurred without the MRP catalyst.

Managers indicated that changing business conditions have been responsible, to a large extent, for creating the nature of today's material management atmosphere. Expanding procurement lead times, increased product and component complexity, general inventory reductions on the part of suppliers and increased competition have all made impacts. Even without MRP, company desire to reduce inventory investment would have resulted in stock level reductions and many of the attendant difficulties. Similarly, excessive procurement lead times demand a quickly reacting or nervous system in order to identify requirements as soon as possible. In many respects, MRP and the impacts described in prior sections are all

results of contemporary business conditions:

> As inventory pressure increased people started looking for help. We [material managers] were involved with APICS [American Production and Inventory Control Society] so MRP was proposed. Top management took a do-what-you-need-to-manage attitude. [13]

> We [purchasing] used to be able to order parts when we ran out and not interrupt things too badly. But material just isn't as readily available now. [14]

MRP's perceived role as a cause of organizational change or another result of other conditions varied according to level and function. Purchasing personnel at all levels and level four managers recognized the larger system more often than employees engaged in other activities.

3. MRP Effectiveness

Acceptance of MRP as a valuable tool by material managers and production supervisors was alluded to in prior sections. All of the personnel interviewed regarded MRP as an improvement over prior techniques and considered their system a successful application of the process.

Equally as unanimous, however, was the opinion that full MRP benefits were not being obtained. Material managers were concerned with improvements in the production and material support plan. Managers cited the elimination of excessive manual manipulation of the plan as the major area of potential system improvement. Input errors and the failure of all personnel to follow MRP procedures were most often cited as the reasons for limited success in this area.

Production supervisors, however, indicated that failure of the materials management department to fully utilize available MRP system capacity was responsible for avoidable losses in MRP benefits. MRP's simulation capacity was specifically identified as underused. The expected success of a material support plan could be simulated using component delivery information available in the system. Production contingency planning was the stated goal of such a simulation.

VI. CONCLUSIONS

The conclusions of this research are based on the analysis of the data presented in Chapter V and a retrospective evaluation of the investigation. Conclusions relative to the study hypotheses are presented first. They are followed by comments on the investigation and overall conclusions of the research.

A. EVALUATION OF HYPOTHESES

This investigation achieved varying degrees of success in the identification and measurement of the impacts of MRP on an organization's material management functions. Evaluations of the study hypotheses as defined in Chapter IV are presented in this section.

1. Hypothesis Number One: Organizational Structure

The data supported the hypothesis that MRP influences the structure of material management functions within a company. Expected effects, however, cannot be determined without considering other factors.

Generally, conversion to a computerized MRP system will increase the total number of personnel engaged in material management activities. The expected increase is a net result of an increase in the number of material control positions which is partially offset by a reduction in the number of planning positions. The latter manning-level change

may not occur if the replaced inventory planning system did not rely on a large clerical input. The former change may not occur if the material storage and handling operation was conducted with a high degree of accuracy and control prior to MRP introduction. The experiences of the study locations indicate, however, that MRP requires more people to operate than do traditional systems.

Senior material managers indicated that consolidation of the various functions in one major department is a structural characteristic that enhances MRP operation. Actual study-location experieneces, however, were inconclusive on this issue as only minor responsibility changes were recorded, and one change was in a direction away from consolidation. If MRP is a consolidating force, it does not produce major structural changes by itself. Other factors like company size must also be present.

2. Hypothesis Number Two: Work Content

The data supported the hypothesis that MRP changes the work content of personnel engaged in material management functions. The degree of impact varied primarily with hierarchial level.

The greatest MRP-induced changes occurred at level one. Compared with conventional production and inventory control procedures, personnel engaged in MRP planning functions spend less time performing repetitive clerical tasks. The manual generation of material requirements has been eliminated as a planning responsibility in favor of analyses of system

provided information. In support of the new job requirements, planners require a greater knowledge of company products and manufacturing processes than do similar positions using other systems. Planning positions are not as physically active as a result of MRP. They are, however, more effective and require more capable personnel than are required for similar positions using conventional techniques.

Level one material control positions have also changed with increased operating discipline the primary impact. Under MRP, material control functions are more systematic and they reflect the addition of control procedures designed to insure inventory accuracy. Material control personnel also require knowledge of MRP system elements and are more involved with inventory problems throughout the manufacturing activity than would be expected under non-MRP systems.

The work content of level three material managers and their assistants has also been significantly affected by MRP. The monitoring by supervisors of the use of the MRP system by subordinates has, to a large degree, replaced previous functions involving the collection and organization of information for the use of higher levels of management. Management of a people-MRP-system combination is more difficult than management using less-integrated inventory control techniques. All MRP elements are interdependent and important to the overall success of the system. The required high performance of each element has caused supervisory positions to

be more important to the company than are similar positions using other production and inventory control systems.

Level four material management positions were directly affected by MRP the least of all levels. Managers at this level are faced with increased knowledge demands, and the coordination of subordinate functional areas has taken on new importance as a result of MRP implementation. However, fundamental changes in positions at this level are more a function of changing external conditions and the company's inventory policies. MRP takes on importance as a major element of a level four job only in relation to the accomplishment of business objectives.

3. Hypothesis Number Three: Departmental Interdependence

The data supported hypothesis number three relative to the departmental interfaces considered in this research. All areas were not explored, and conclusions are necessarily confined to the material management and production areas.

The data substantiated the requirements for a high degree of integration of all inputs to MRP-coordinated manufacturing and inventory control activities. Each function adversely affects other functions if done improperly. The great number of personnel having a significant influence on total system success demands teamwork with all areas performing up to standards.

Compared with inventory control systems based on statistical concepts, production's input on the quality of

MRP-directed material support is increased. Material management's success in providing effective support is a function of strict production compliance with an intended schedule. Mutual dependence is, therefore, reinforced.

MRP requires material and production planning personnel to work more closely with production supervisors. Planning responsibilities were organized along manufacturing process lines in a manner similar to the organization of production responsibilities. This was done to improve communication between the two groups. This arrangement also has costs as it splits planning responsibility for individual products and erodes the product knowledge of the planning group. Interdependence between planners with partial responsibility for the same product also increases. Whether a process arrangement was in place prior to MRP or a change to that planning alignment was made after implementation does not matter as the resultant long-run effects are the same.

The increased interdependence between material management functions and between those functions as a group and production was not viewed as destructive. People were sensitive of the effects of errors in other sections on their own jobs. Traditional parochial viewpoints regarding production-run lengths, general inventory levels and planning changes were also expressed. However, managers recognized that MRP is a fact of company life. The knowledge of the shared responsibilities for the system's success has done much

to clarify relationships between functions and managers at all levels and has promoted a cooperative company climate.

4. Hypothesis Number Four: Informal Systems

During this investigation a few impacts of MRP that relate to informal systems were recorded and described in Chapter V. Data collected in this area during the research are, however, inadequate to fairly evaluate hypothesis number four.

Formalization of system procedures and the surveillance of informal systems were reported by material management supervision. These actions were confirmed by employees. It was not clear, however, whether these actions affected only the work content of material management employees or the informal operating mechanisms at work within the formal system.

The reported effects of MRP on the importance of material management positions, as perceived by study-location personnel, must be viewed in the same light as the formalized procedures as far as informal systems are concerned. All information considered, it seems very likely that material management positions at all levels have increased in importance as a result of MRP and other factors. It is probable that these increases have affected employee status levels and other informal system aspects. However, impacts on informal system operations were not adequately identified in this study. The failure of this research in this area is discussed later in this chpater.

5. Hypothesis Number Five: Employee Displacement

The data supported the hypothesis that MRP has been a cause of employee displacement in using companies. Actual displacements and potential displacements were noted.

In the material control area, MRP generally requires more qualified personnel than do conventional systems. This requirement is related to the manning-level increase discussed under structure. Companies that pursue inventory accuracy to the degree required for successful MRP operation will already have experienced this requirement with or without MRP.

Other displacement actions are of a longer run nature and may be less identifiable. The personnel selection criteria for new material planning functions discussed in Chapter V are, at this point, mostly intentions. The few study-location personnel selected under the new criteria are relatively new employees. The appropriateness of the criteria has not been conclusively tested and may change with experience. Some movement of personnel credentials in the direction recommended by material management supervisors should, however, continue to be expected.

B. EVALUATION OF THE INVESTIGATION

During the investigation and analysis phases of this study, weaknesses in research methods were identified. A critical evaluation of the investigation is presented in this section.

1. Critique of the Investigation as Conducted

The investigation as conducted appeared successful in identifying, with some degree of confidence, MRP impacts in the areas of structure, work content and employee displacement. The primary data collection technique of interviewing personnel with before-and-after-MRP experience was effective in these areas.

Data collection in the area of interdependence was more difficult and somewhat less effective using the before-and-after interview technique. Changes in interdependence levels are often a matter of degree and are most difficult to attach to a particular event--like MRP introduction. The investigation as designed could, however, have been more productive in the interdependence area if interview coverage had extended to other functions such as general management, marketing, engineering and accounting. Expanded coverage may also have provided more information on MRP impacts on level four managers who may deal with functional-area interfaces in the omitted areas more often than subordinate levels of management. Deficiencies in the data concerning informal systems were due largely to investigation approach and are discussed in the following section.

2. Critique of the Investigation Design

In retospect, certain changes in the study approach may have provided more information. First, the selection of only MRP companies as study locations may have been an error.

Inclusion of at least one company that utilized a more conventional inventory control system may have provided valuable comparisons. Such comparisons may have been particularly helpful in identifying changed departmental-interdependence levels in MRP companies.

A second possible improvement in the investigation approach involves the division of interview time between initial and follow-on study locations. A small increase in the number of initial interviews would probably have identified the majority of impacts on structure, work content and employee displacement recorded in this research. A reduction in the number of follow-on study locations and more extensive follow-on interviews at one or at the most two selected locations may have produced more data on departmental interdependence and informal systems. In combination with the previous suggestion, extensive study of one MRP and one non-MRP company following more general discussions with several MRP-equipped locations may have been a more productive investigative design than the approach selected. It is unlikely, however, that any investigative format incorporating external data collection would be entirely successful in measuring MRP impacts on informal systems.

C. GENERAL CONCLUSIONS

In addition to the impacts discussed in prior sections of this report, the investigation and analysis suggested a few conclusions of a general nature. First, in addition to

generating new demands, MRP also identifies problem areas that have always existed in companies. The new process alters accuracy versus cost-to-achieve-accuracy standards and forces management to deal with problems that had previously been tolerated. The combination of new requirements and higher standards for old problem areas could result in a large addition in the total number of control systems utilized by a company. MRP may rival the budget in generating control mechanisms.

Second, nearly every person interviewed considered inadequate training of personnel to be a major cause of their own MRP operational problems. The almost unanimous view of inadequate training expressed by personnel at all management levels in discussing their own areas of responsibility as well as other areas indicates that a solution to the training problem is more difficult than might be expected. Traditional supervisor or experienced employee workload breakdowns may require alteration to provide more time for meeting training responsibilities.

Finally, MRP may alter the general role of materials management in the organization. Although many factors determine a department's influence, the directive nature of MRP and the magnitude of company resources expended during the MRP-management effort may alter a company's power structure in the direction of the materials management group.

VI. RECOMMENDATIONS

As initial research, this thesis was designed to investigate materials requirements planning from an organizational perspective and to begin to identify system impacts on organizational elements. Greater understanding of system elements may lead to answers to some of the operational problems being experienced by MRP users in industry. The past chapters provide information that may be helpful in that regard. However, specific recommendations of a problem-solving nature cannot be made based on the findings of this study. This research and studies that follow may suggest a framework for an organizational-MRP problem assessment, but the complexities of MRP and the environment in which it operates demand a comprehensive study tailored to each activity's needs as a basis for any corrective action.

The potential for further research in this area is almost limitless. A study similar to this one but conducted in the manner discussed in Chapter VI is one recommendation. The following additional areas for further study are recommended as logical follow-ons to this research.

A comparison of two MRP companies, one with an effective MRP operation and one experiencing severe MRP operational problems, could provide valuable information if the obvious problem of identifying one company in each category could be overcome. A potentially effective corollary to that suggestion

is a study of the effects of company resources existing at the time of MRP implementation on eventual MRP effectiveness. Such factors as personnel experience with computerized information systems, employee education, type of prior inventory control system and organizational structure should be considered. The effects of these factors on eventual MRP performance may help identify requirements for system success and suggest steps that could be taken to prepare a company for MRP.

Quantification of several factors could be incorporated into any of the research formats recommended above. Measurement of manning levels, salaries of material management personnel and educational levels could serve to replicate several of the effects of MRP discussed in this study.

The importance of materials management in industry has increased in recent years. The added emphasis has promoted the development of improved production and inventory control techniques. Many of the new techniques are dependent on modern computer processing of information and integrated database management. Materials requirements planning is a major development in this area that is expanding in use. MRP systems have proven to be effective inventory management tools. They also produce significant impacts on organizations and the people in those organizations. This has been a study of the organizational impacts of materials requirements planning on using companies.

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